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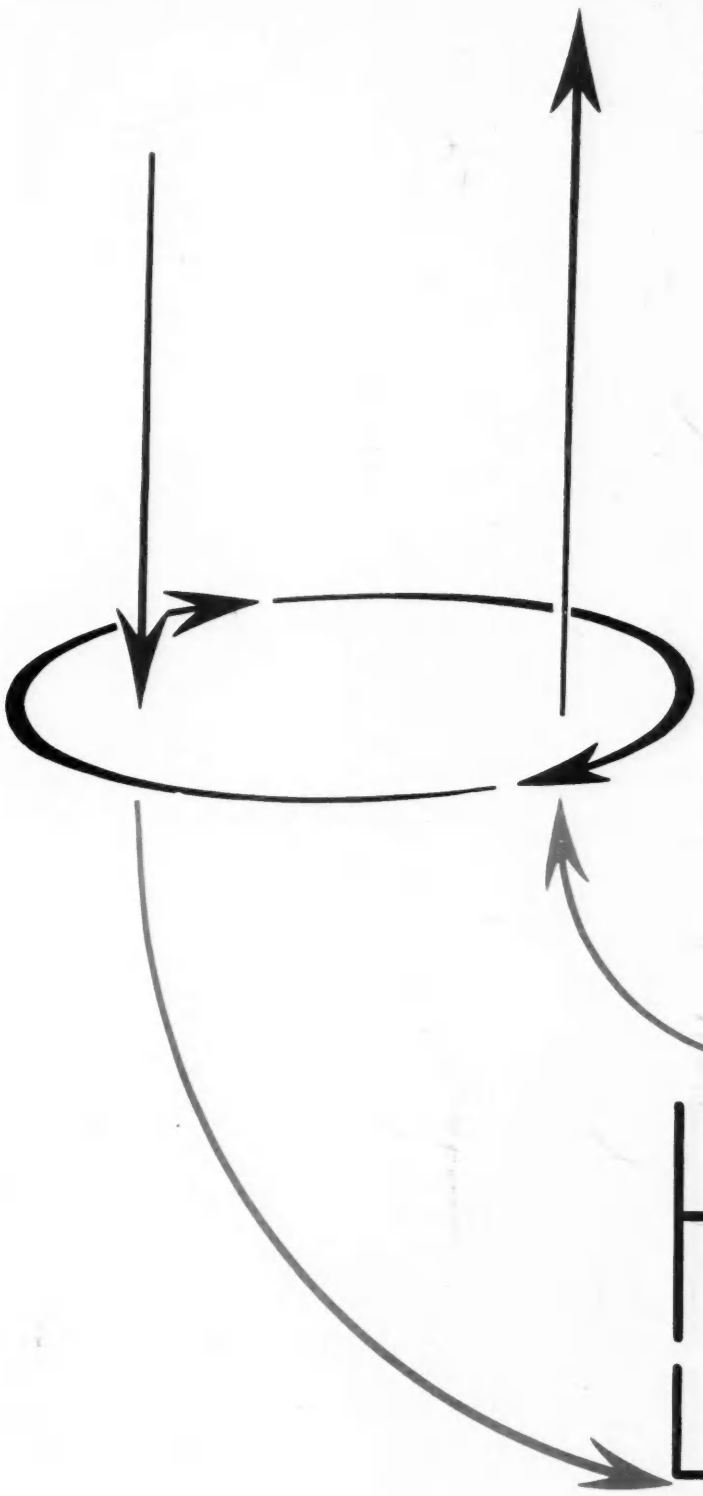

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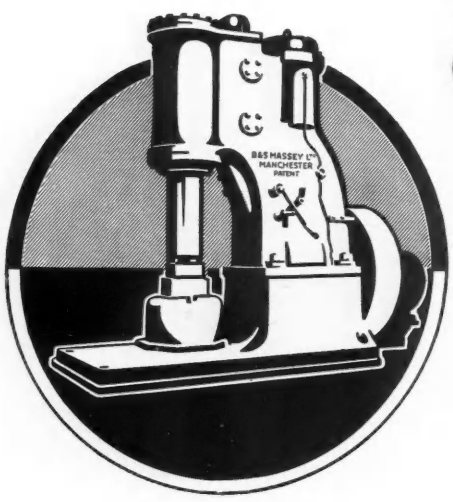


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# A Seven-Day Journal

## London Passenger Transport Board's Report.

THE report of the London Passenger Transport Board for the year ended June 30th, 1935, has just been issued. It is a quite considerable volume, a large part of which is taken up by financial accounts. Reference is made to the various works of co-ordination that have been necessary as the result of the Board taking over numerous concerns in which conditions of operation differed, and to the arrangements for bringing about uniformity of fares charged and the like. Of more interest to engineers is the section dealing with works that are to be carried out under an agreement made with H.M. Treasury whereby the principal and interest of loans up to £40,000,000 are guaranteed. Most of these works were mentioned in a Journal note of June 14th, but parliamentary sanction has still to be obtained for some of them before work can be started. Among other works they comprise the electrification of certain L.N.E.R. lines in North-East London and extensions of the tube railways in the same area; and corresponding electrification of G.W.R. lines and extensions of tube railways in the west. In addition, several stations are to be reconstructed and trams to be substituted by trolly-buses. In another section reference is made to the effect of the recommendations of the Amulree Committee upon the operation of coach services in the London area. It will be remembered that arising from the recommendations mentioned, the majority of coach routes were diverted from the central area of London. The Board states that as a result the number of passengers carried has decreased by nearly 26 per cent. and the receipts by 24 per cent., although the coach mileage withdrawn was only 9½ per cent. In view of these facts and of the altered arrangements by which coach routes no longer terminate in the central area, the Board proposes to seek authority for the reinstatement of certain coach services in the central area. Reference is also made in the report to the reasons why the Board found itself unable to aid in the establishment of a service of river buses on the Thames.

## Street Lighting.

IN its interim report to the Minister of Transport, the Departmental Committee on Street Lighting gives a minimum standard of illumination deemed to be sufficient to enable vehicle drivers to drive with safety at 30 m.p.h. without headlights on all traffic routes. It is impossible, the Committee states, to determine with accuracy from the available statistical information the extent to which bad lighting is the immediate cause of road accidents in this country. Observations lead to the conclusion that "pools of darkness" resulting from uneven distribution of light on the road surface, especially in the case of inadequately lighted roads, render it difficult for motorists to judge distances and for other road users to estimate the speed of approaching vehicles. Marked variation of lighting in any one thoroughfare may also cause uncertainty in the mind of the motorist regarding the necessity for using his headlights. On the whole, the Committee agrees with the opinion that street lighting, which may be described as patchy, may be worse from the point of public safety than no lighting at all. In support of the view that consideration should be given to the question of confining responsibility for lighting to large bodies, such as County Councils and County Borough Councils, attention is called to the fact that on a popular exit from Central London five authorities control the lighting of 4 miles of the route. Lamp standards vary in height from 10ft. to 22ft., and the distance between them from 15 to 130 yards. In some cases the posts are confined to one side of the road, whilst in other cases a staggered arrangement has been adopted, with the result that the standard of lighting ranges from excellent to bad.

## More Continental Steel Required.

IN making their arrangements for limiting the tonnage of Continental material to be imported into this country, the British steel makers would appear to have under-estimated the requirements of their home market. In several departments there is an acute scarcity of material, and consumers complain not only of the difficulty they have in obtaining deliveries against their contracts, but also in placing business for forward delivery. Some attempt has been made to relieve the situation by allowing more Continental semi-finished material to be imported than was originally decided upon, but this has been of little real benefit in easing the position. The British steel makers also have agreed not to deduct the tonnage by which the Continental imports exceeded the quota for the period ending in August from that for the following three months, thus making available for the British market about 12,000 tons of Continental steel bars. It is understood that within the last few days, in addition, an arrangement has been made by the British Iron and Steel Federation by which 10,000 tons of Continental steel will be delivered each month for the next six months over and above the quantities provided for in the quota. There is no doubt that the difficulty of obtaining supplies, and expectations that advantage would be taken of the position to raise the prices of steel have been largely responsible for the buying movement. The recent understanding between associated and unassociated makers of small bars to raise the price by 10s., and the increase last week in the prices of Midland irons by 4s. to 5s. per ton, and in the case of No. 3 and No. 4 bars by 7s. 6d. per ton, have all contributed to cause some perturbation amongst buyers. So far, no meeting of the steel makers, without which a price advance cannot be made, has been called, and a meeting which had been arranged to take place at Harrogate has been postponed, as it clashed with the election date. It is suggested that the steel makers could put forward a very good case for advancing their prices, although it was generally understood when the duties on steel were imposed that if the British works found it possible to operate at capacity as a result of Protection lower rather than higher prices might be anticipated.

## Improvements to British Aircraft.

THE report of the Aeronautical Research Committee for 1934–35 was issued on Monday last. It discusses various experiments in the design of aircraft which have been made during the year. According to the report, progress has been good in the direction of reducing the noise of aircraft, especially with regard to the design of satisfactory exhaust silencers. Some of these have achieved an overall noise reduction of 30 decibels, thus bringing the exhaust noise to a value lower than that of other engine noises, such as valve clatter, &c., and the report points out that the noise due to motion through the air may easily be greater than that of an engine fitted with a silencer. As aerodynamic efficiency increases, this noise, too, will probably be reduced. The report cites this and similar cases where the problem of silencing the aeroplane is complicated by the fact that the silencing of one noise brings another into relief, so that the final achievement may take years to accomplish. The Royal Aircraft Establishment is mentioned as having evolved an automatic mixture control which produced savings of fuel of between 14 and 30 per cent., according to conditions of flight. Experiments at Farnborough have shown that ice formation in the fuel supply could be eliminated by the addition of a small quantity of alcohol to the petrol. An apparatus delivering alcohol automatically at the onset of freezing has been devised, and has, the report states, passed laboratory tests satisfactorily.

## State Aid for Railway Works.

ON Monday evening, November 4th, it was officially announced that, following some months of negotiations, the Government has just reached an agreement with the four main line railway companies whereby on the grant of the necessary powers by Parliament the companies will be enabled to put in hand a programme of reconstruction and improvement which will cost some £30,000,000. The financial arrangements resemble closely those made in the agreement with the London Passenger Transport Board and the main line railways, recorded in our Journal note of June 14th last. As far as practicable, all plant, machinery, and materials, also manufactured articles, are to be wholly made in the United Kingdom, and preference, other things being equal, is to be given to firms in the Special Areas. In a supplementary statement made by the railway companies on Tuesday, November 5th, it is stated that the works included in the lists approved by the Government will place the companies in a position to carry increased traffic with efficiency, and will, it is considered, ultimately yield a profit to the shareholders; but it will be some time before works of this character may be expected in all cases to show full fructification, and for this reason the provision of a loan at a lower rate of interest than otherwise obtainable was an essential condition of the works being undertaken. The work to be carried out includes extensive electrification on the Southern Railway, the L.M.S. system in the Wirral Peninsula, and the electrification of the Manchester-Sheffield L.N.E.R. line. The reconstruction of Euston Station is also included in the work.

## The Employment Figures.

IN a broadcast address given on Saturday, November 2nd, Mr. Neville Chamberlain stated that the October unemployment figures would, on the month, show a reduction of 42,220. According to the Ministry of Labour figures, issued on Monday, November 4th, it is estimated that on October 21st, 1935, there were approximately 10,492,000 insured persons between the ages of sixteen and sixty-four in employment in Great Britain. That figure is 14,000 more than the revised figure for a month before, and 270,000 more than a year before. It is pointed out that the South Wales coal stoppages have contributed to reducing the number of employed shown by the October 21st figures. Among those trades which have shown an increase in employment during the past month, the following may be mentioned:—Coal mining, engineering, shipbuilding and ship repairing, and motor vehicle and aircraft manufacture. At October 21st the numbers of unemployed persons on the registers of the unemployment exchanges in Great Britain were 1,595,689 wholly unemployed, 238,866 temporarily stopped, and 81,835 normally in casual employment, making a total of 1,916,390. This figure was 42,220 less than the number on the registers at September 23rd, 1935, and 203,245 less than a year before. The total of 1,916,390 unemployed comprised 1,527,077 men, 62,762 boys, 273,935 women, and 52,616 girls.

## A North-East Coast Survey.

A NEW survey of the industrial position of the North-East Coast has been prepared by the staff of the Economics Department of Armstrong College, under the direction of Mr. E. D. McCallum. It supplements the industrial survey made for the Board of Trade in 1931 and covers the years of the world economic depression. An introduction points out the difference between a cyclical trade depression and a local depression, such as that of the North-East Coast, which has come to be regarded as more or less permanent. The report points out that further economic recovery waits on the expansion of international trade, which is delayed by such agreements as quotas, &c., holding the trade level at its lowest value, by failure of the international monetary standard, and by general economic nationalism intensifying the effects of the other nations' depressions and therefore ultimately of its own. On the North-East Coast unemployment is reported to have been twice as heavy in the years of depression as it was in pre-depression years and in both periods about twice as severe as in the rest of the country outside the depressed areas. The survey points to an increase, however, in employment in the lighter industries and services in the area. It also brings out the remarkable shift in the distribution of employment from the basic and in the main export industries to the lighter and mainly home consumption industries and services. The report notes that the labour supply is adjusting itself slowly to the changing economic "pattern" of the area. The extent to which this change is due to the entry of new labour to the ranks of the more prosperous industries and how far to the exchange of existing labour from the older industries it is impossible to ascertain.

## New Naval Orders.

THE Admiralty announces that, subject to the settlement of certain points of detail, it has decided to entrust the construction of the flotilla leader and destroyers of the 1935 naval programme to the following firms. The leader is to be built by Cammell Laird and Co., Ltd., at Birkenhead, while two destroyers each are to be allotted to John Brown and Co., Ltd., Clydebank, R. and W. Hawthorn, Leslie and Co., Ltd., of Hebburn-on-Tyne, J. Samuel White and Co., Ltd., of Cowes, Isle of Wight, and Yarrow and Co., Ltd., of Scotstoun, Glasgow. These contracts will dispose of all the destroyers provided for in the 1935 programme. In order to complete that programme the following orders have still to be placed:—Three submarines, one submarine depôt ship, three minesweepers, one convoy sloop, one surveying ship, and seven smaller craft. It may be pointed out that all the ships referred to above are for the usual maintenance purposes of the fleet and that they do not form a part of any rebuilding scheme. All the ships of the 1934 programme are now on the stocks and several of the smaller vessels are approaching the launching stage.

## Cornish Engines Preservation Fund.

FOLLOWING a well-attended meeting held at Murdock House, Redruth, last month, the names of an executive committee, endowed with power to add to its numbers, which will deal with the preservation of Cornish engines and administer a fund to be credited for that object, have just been announced. Those serving on the committee include Mr. Horton Bolitho, Mr. Josiah Paull, Mr. A. Pearse Jenkin, Mr. H. W. Dickinson, Mr. J. Blight, Mr. Treve Holman, Mr. F. C. Cann, and Colonel Giles Oates. The first engine to be dealt with is that at the Levant Mine, which was designed by Francis Michell in 1840 to 1841. It is of the beam type with the valves worked by plug rod and plug handles. The engine can now be bought for scrap value, and Mr. A. F. H. Stephens, of Camborne, who is the agent for the Trewellard Estate, on which the engine-house is situated, has stated that no difficulties would be placed in the way of its acquisition and that the engine-house and a right of way to it could be ensured for a mere peppercorn rent. About £300 will, it is estimated, be required for making minor repairs and maintenance. Support has been promised by many engineers and others interested in the history of engineering, and subscriptions may be sent to the joint secretaries of the committee, Mr. W. Tregoning Hooper, at Falmouth Observatory; and Mr. W. A. Michell, Coachlane, Redruth. Recently, owing to the decline in mining and the "grid" extensions, many Cornish beam engines have been scrapped, and it is estimated that only three are now at work in Cornish mines.

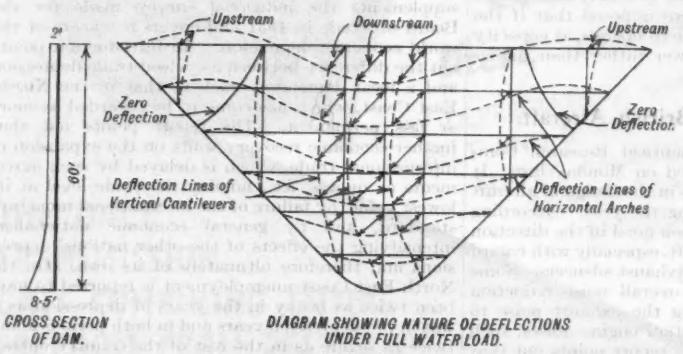
# Single-Arch Masonry Dams.

By GEORGE BRANSBY WILLIAMS, M. Inst. C.E.

No. II.

(*Concluded from page 422, October 25th.*)

*Experiments of the United States Dam Committee.*—The constantly increasing number of arched dams erected in the Western States of the U.S.A., and the uncertainty that existed in regard to the distribution of the stresses in this type of dam, led to a comprehensive series of experiments being inaugurated in the summer of 1927 by the Bureau of Reclamation in conjunction with the Engineering Foundation




CROSS SECTION OF DAM. FIG. 13a

DIAGRAM SHOWING NATURE OF DEFLECTIONS UNDER FULL WATER LOAD. -STEVENSON DAM- FIG. 13b.

"The Engineer"

Arch Dam Committee and the University of Colorado. The primary object of the tests was to obtain definite information regarding the safety of the dams being erected by the first-named authority. Tests of model dams were made, and a full-sized dam, 60ft. high, was built in the Stevenson Creek on the San Joaquin River, in California. An elaborate series of instruments was fixed in this dam to measure the stresses, deflections, and temperatures in the dam. A cross section of the dam is shown in Fig. 13*a*. Fig. 13*b* shows diagrammatically the deflection of the dam under full water pressure. The report of the experiment was issued in 1931. This contains very full information as to the results of the experiments on the Stevenson dam, as well as on a model of that dam, which was tested to destruction, and on a model of the Gibson dam. The latter is a dam about 200ft. high, 15ft. wide at top, and 87ft. at the bottom, with a radius of about 400ft. at the top. The model was made to a scale of 1/68th and loaded with mercury. Mercury has a specific gravity of 13·6, so the stresses in the model would be in the ratio $\frac{13 \cdot 6}{68}$, or about 20 per cent. of those in the actual dam under full water pressure.

*Trial Load Method of Analysis.*—The report states that the experiments had established the accuracy of the trial load method of analysis that has been the basis of the design of arch dams constructed by the Bureau of Reclamation for several years. This method had been fully described during the period of the experiment in a paper by C. H. Howell and A. C. Jaquith, read before the American Society of Engineers in 1929. It is based on the assumption already referred to that an arch dam is composed of systems of horizontal arches and vertical cantilevers, that each system carries a proportion of the total load, and that the deflections of the two systems are equal. A series of assumed proportional loads is applied to each system. When a proportional loading has been found that gives approximately equal deflections for all points in both systems, the stresses are computed and considered those that will obtain in the dam.

The authors of the paper considered that it had become generally recognised that the "cylinder" formula, when applied to arch dams, resulted in designs which were uneconomical, the lack of economy increasing very rapidly as the size of the dam increased. Moreover, although no dam so designed had actually failed, some of them were probably stressed to the safe limit. On the other hand, the inadequacy of the method of determining the distribution of the load between the arches and cantilevers on the basis of the relative rigidity at the crown is graphically illustrated by the diagrams, Figs. 14*a* and 14*b*.

Assuming a valley of cross section as in Fig. 14*a*, the cantilevers at A and B being of the same height

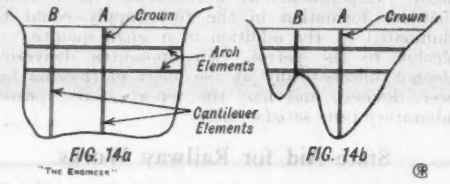



FIG. 14a FIG. 14b

"The Engineer"

and cross section (assuming the arch elements are of uniform thickness) will theoretically deflect the same amount under equal loads. Under uniform load the arch deflection at the crown A will be much greater than at B. Hence, if the deflection of the arch equals that of the cantilever at A, it cannot do so at B. Hence, no uniform distribution of loads between the two systems at all points is possible.

In Fig. 14*b* the cantilever at the hump B will carry more of the load than at other points, and the arch will actually be subject to a negative load. It is evident that any general expression for the proportional loads must take into consideration the shape of the valley across which the dam is placed. No such expression has been developed, and it is necessary to obtain the deflection and proportional loads at numerous points in order to obtain even an approximate solution.

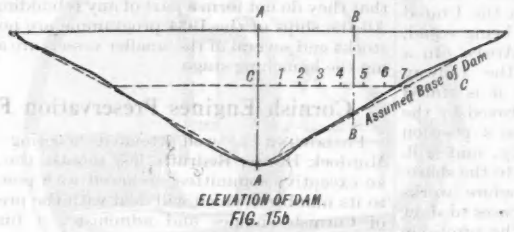
On the assumption that all the load is carried by vertical and horizontal elements, there is some definite division of the load that will give equal deflections in both systems. If enough trials of proportional loads on each system are made, approximately equal deflections for arch and cantilever at all points will finally be found for any assumed temperature change. The computed stresses due to these loads (modified by Poisson's ratio) will be more nearly correct than stresses obtained by any method ignoring the cantilever element or computing its effects at one section only.

The authors gave an account of the gradual development of the method employed. In the first analyses the stresses were computed on the assumption that steel reinforcement would be required to resist tension and transmit it across the construction joints. As the methods were improved, it was found possible to eliminate the computation of tension in the arch elements by varying the thickness of arch and assuming interior arches of regular shape at the horizontal section where the preliminary computation showed tension. These arches are completely enclosed within the constructed arches and entirely in compression. The largest possible interior arch that could be drawn without showing tension was used in the final analyses. Later it was found possible to consider the arch action to be confined entirely to the irregular shape, whatever it might be of the uncracked concrete forming the actual interior arch. The part of the base of the cantilever not in compression is likewise excluded in computing stability.

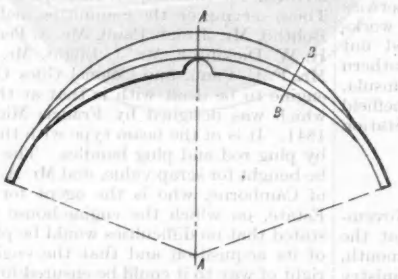
The methods of analysis were illustrated by practical examples. One of these which, at the time the paper was written was still in the preliminary design stage, is illustrated in the diagrams below. The maximum height of this dam is about 256ft. The upstream radius at the top is 388ft.; the angle subtended is 133 deg. The thickness at the crown is 10ft. at the top and 46ft. at the bottom. In order to show the method adopted the cross section of the dam, load diagram and deflection curve of two cantilevers are shown for the crown and at a point between the crown and the end of the dam; the load and deflection curve for one of the arch slices, with a sketch plan and elevation of the dam, are also illustrated. In the paper similar diagrams were shown for the whole of one side of the dam.

Similar information was supplied in regard to the Horse Mesa dam and the Gibson dam. The former is probably the most slender dam for its height in existence; 271ft. high, it has a thickness of 8ft. at the crest. At the base its maximum thickness is 40ft. at the crown and 61ft. at springing. The upstream radius is 240ft. at the crest and 195ft. at the base. The downstream radius varies from 232ft. at the crest to 100ft. at the base. The angle subtended at the crest is 112 deg.; this increases to 121 deg. at a depth of 100ft., and then decreases to 77 deg. at the base. This dam is an example of bold and scientific engineering.

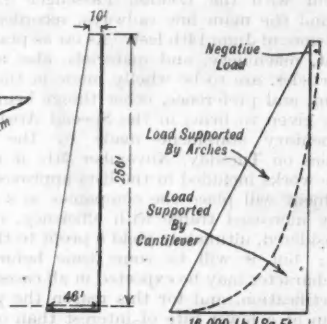
In Messrs. Howell and Jaquith's paper the arch




ELEVATION OF DAM. FIG. 15b

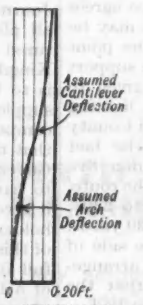



SKETCH PLAN OF DAM. FIG. 15a

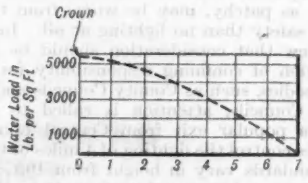



CROSS SECTION OF DAM AT CROWN. FIG. 15c

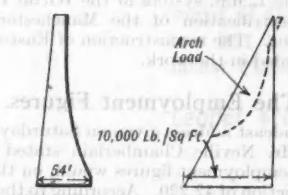
LOAD DIAGRAM AT CROWN CANTILEVER. FIG. 15d




DEFLECTION CURVES. FIG. 15e

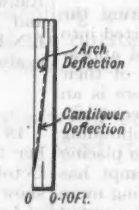



LOAD DIAGRAM FOR HORIZONTAL ARCH SLICE C.C. FIG. 15h

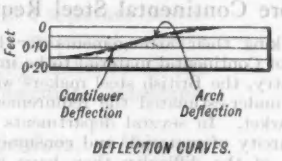



CROSS SECTION OF DAM AT B.B. FIG. 15f

LOAD DIAGRAM AT B.B. FIG. 15g




DEFLECTION CURVES. FIG. 15h




DEFLECTION CURVES. FIG. 15i

"The Engineer"

deflections were computed from the equation

$$\Delta_y = \int \frac{M x \, d s}{E I}$$

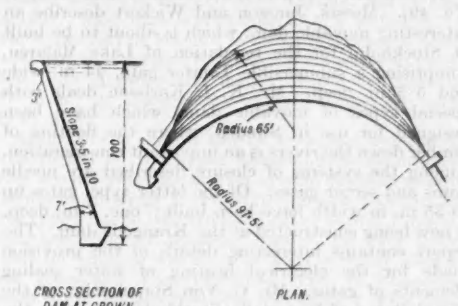
M being the total bending moment at any point and E = 2,000,000 lb. per square inch.

The deflections of the cantilevers were obtained as follows:—The moments about the neutral axis were computed at various heights, loading the structure with the weight of concrete, weight of water, on the upstream face, horizontal pressure due to assumed proportional load, negative load due to unloaded arches at top (where such exists). In places where the resultant fell outside the middle third of the section, the moment of inertia was taken only for the portion of the section in compression and the moments were considered as acting about the neutral axis of the compressed portion.

The equation used was

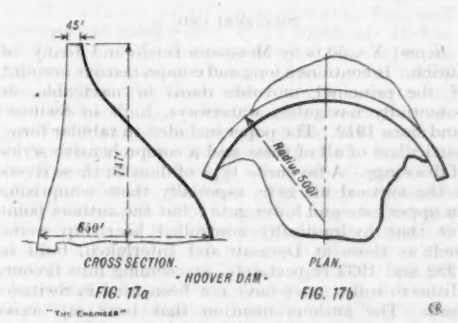
$$y = \iint \frac{M}{E\,I}\, dx\, dx$$

In the discussion and correspondence on Messrs. Howell and Jaquith's paper it was suggested that other factors besides those actually taken into consideration required to be included in the investigation. The necessity for some simplification of the method was suggested by several contributors. Mr. L. F. Mensch proposed a method of analysis which would disregard cantilever action and design the dam as a series of inclined arches, the inclination being fixed by the ratio of the water pressure per square foot to the weight of the inclined ring per square foot. He stated that tensile stresses are produced in the arch rings when the ratio $\frac{\text{Rise of arch}}{\text{Thickness of ring}}$ is less than 3. Mr. F. Vogt suggested that the cylinder formula could be made valid for arch dams by using a multiple pressure grouting system which could be made to apply initial stresses to the dam in such a way that the stresses due to load, cooling, shrinking, and grouting could be approximately equalised. Not only would the arch effect be improved, but the stresses in the cantilevers could be reduced and to some extent tensile stresses could be converted into compression.




- DAM ON NANAIMO RIVER, BRIT. COLUMBIA. -

FIG. 16a FIG. 16b




- HOOVER DAM -

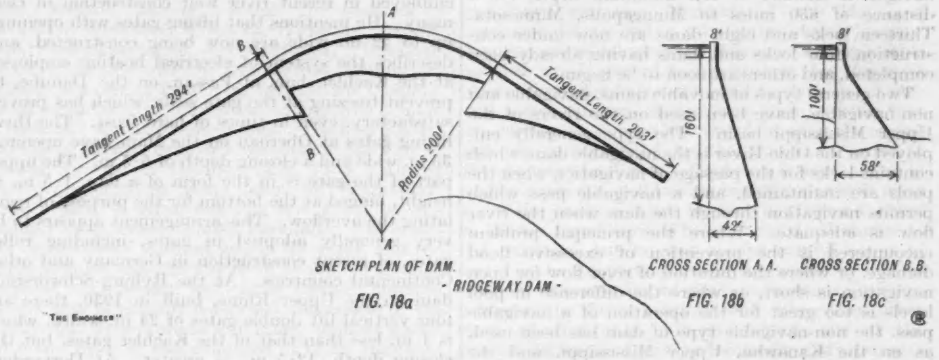
FIG. 17a FIG. 17b

*Nanaimo River Dam in British Columbia.*—Mr Vogt has adopted this system in dams which he has designed. An example of this form of construction is furnished by a dam built on the Nanaimo River in British Columbia, which is illustrated in Figs. 16*a* and 16*b*. This dam is 100ft. high, and the top 80ft. is a thin wall varying in thickness from 7ft. to 3ft., with an overhang of 31·5ft. downstream on the centre line. The radius of the extrados at the crest is 97·5ft. and at the base 65·0ft. A grouting pocket was constructed on the centre line of the dam, and into this grout consisting of one part Ciment Fondu to two parts fine sand were poured at one operation. On completion, a pressure of 30 lb. per square inch was put on the grout at crest level and maintained for twenty-four hours. No reinforcement was used in the dam.

*Present System of Design.*—The trial load method of analysing the stresses in high arched masonry dams appears to have now become more or less general in the United States. Its most recent developments have been described by Mr. Ivan E. Houk in his articles published in the issues of THE ENGINEER of August 4th and 11th, 1933, and July 5th and 12th, 1935. It is a complicated and laborious method, but has been found satisfactory and has enabled much higher stresses to be provided for than were considered safe in the past. Greater economy is obtained, and dams are now built or under construction of a height which would not have been dreamt of at the beginning of this century. It has become difficult to draw any hard-and-fast line between arched dams and curved gravity dams. Nearly all gravity dams of moderate length are curved in plan, and in such a case some part of the load is transmitted by arch action to the hillside, whilst in any arched dam a portion of the load is carried by cantilever action.

In recent years more accurate provision has been made for temperature changes, whether caused by seasonal changes in the atmospheric conditions or by the setting heat and subsequent cooling of the cement. The effect of uplift has been studied. It is usual to allow for upward water pressure under the base of dams varying from some fraction of the full water pressure at the water face (usually between one-fourth and two-thirds) to nil or tailwater pressure at the downstream face. This factor is in most cases considered of less importance in arched dams than in gravity dams.

*Hoover (Boulder) Dam.*—The highest dam in the world so far contemplated is the Hoover (now Boulder) dam on the Colorado River in Nevada, now completed. A plan and cross section of this dam are shown in Figs. 17*a* and 17*b*. It is of a curved gravity section, constructed, like most American dams, of cement concrete. The maximum height of the dam is 747ft., width at top 45ft., and at the base 650ft. The maximum estimated stress intensity is 33 tons per square foot. Special arrangements were made for cooling the interior of the dam and for pressure grouting during construction. The drainage area above the dam is about 175,000 square miles and the reservoir capacity 1,330,000 m.c.ft.




- RIDGEWAY DAM -

FIG. 18a FIG. 18b FIG. 18c

The highest constant angle arch dam is the Pacoima dam at Los Angeles, California. This is 372ft. high, 10ft. wide at the top and 100ft. at the base. The upstream radius at the crest is 336ft. The maximum stress provided for is 32 tons per square foot.

Large arched dams have been built in France and Switzerland. The highest curved gravity dam in Europe is the Le Sautet dam on the river Drac, Department of Isere, France, now under construction. This will be 426ft. high, 10ft. wide at the crest, and 246ft. at the base. The upstream radius at the crest is 233ft.

*Arched Dams with Gravity Section Tangents.*—In most of the dams referred to in this article the arch thrust is transmitted directly to the sides of the valley, which become the abutments. There are also dams in which the arched portion is confined to the deeper central section, the dam being continued by tangential lengths of gravity section, either on one side only or on both. One such dam has been illustrated in Fig. 6 (*ante*), and another is shown in Figs. 18*a* to 18*c*. This is the Ridgeway dam near Hobart in Tasmania. The dam consists of a central concrete arch, 160ft. high above the lowest part of the foundation, with two concrete gravity tangential lengths. Its main features are evident from the sketches.

*Conclusion.*—The comparatively flat slopes of the valleys in Great Britain make them generally unsuitable for the construction of short, high, arched dams. An example of the kind of surroundings in which such dams have been built elsewhere can be found at the south-west end of the Cheddar Gorge, in Somerset. Here there would be no difficulty in constructing an arched dam some 300ft. high and 500ft. or 600ft. long. (This idea is put forward merely as an illustration and not as a practical engineering proposition.) There are few other places in this country where such a scheme would be feasible. Moreover, there has been a prejudice amongst English engineers in the past against arched dams on account of the uncertainty existing in regard to the stress distribution in them. That uncertainty has been largely removed by modern investigations, but it still exists to some extent. On the other hand, the calculations required for the system adopted in America for the design of large dams of this type are so complicated and laborious that they might well deter engineers unfamiliar with them from considering the possibility of such dams except in places where the economy resulting from their adoption would be obvious. Whilst, however, complete arched dams are likely to continue to be rare in this country, there are places where a saving could probably be effected by building the central portion of the dam on a short radius curve and continuing the tangential portions as gravity dams, or as earth dams with reinforced concrete cores. A suggestion on these lines was made by Colonel Pennicuick, the builder of the Periyar dam, twenty-five years ago, at the Institution of Civil Engineers during the discussion on the New South Wales dams, but this suggestion does not seem to have been followed up since. It seems somewhat paradoxical that, whilst there is hardly any form of structure that has so often been designed on the basis of assumptions notoriously at variance with the true scientific facts as the arched dam, yet there seems no form of engineering enterprise that has been in practice more completely successful. Actually, so far as I am aware, no dam of this kind has ever failed except by the undermining of its foundations. This fact is not only a strong recommendation, but also suggests that excessive refinement in the system of preliminary calculations is hardly necessary except for very high dams. In the case of lower dams simpler methods might suffice, at all events for the earlier stages. Standardised designs of arched masonry dams could hardly be evolved for every kind of dam site, but it might be found possible to prepare such for symmetrical V-shaped valleys, with various side slopes and for dams of heights up to, say, 300ft., that could be made to suit many places where such dams are likely to be required, with slight modifications. These standard designs would enable a preliminary estimate of the cost of a dam of this character to be made easily and compared with that of other, alternative, types of dam.

It may perhaps be suggested that the question of the simplification of the design of arched masonry dams is one worthy of consideration by the International Committee on High Dams that is sitting in connection with the World Power Conference.

# XVIth International Congress of Navigation, Brussels, 1935.

No. IV.

(*Concluded from page 370, October 11th.*)

## Modern Types of Movable Dams.

AMONG the "*Communications*" invited by the Inland Navigation Section of the Congress, the subject of movable dams attracted no less than sixteen reports from eleven different countries. The scope of these papers is limited generally to particulars of maximum dimensions attained in the construction of various types, recent developments in design, and means of reducing to a minimum undermining of weir structures. It should be observed that the reports are confined to movable dams or weirs in canalised rivers, such works as crest gates or movable weirs for high dams being excluded from consideration. The reports show remarkable consensus of opinion as to the value to be attached to experiments with scale models as a preliminary to the design and construction of river barrage works. Nearly all the authors deal with this question, and some of the papers record details of model experiments made in hydraulic laboratories. Another interesting development to which reference is made in most of the reports is the provision in many recently built movable dams of electric heating elements in connection with water seals and other movable parts, in order to prevent trouble from ice. The increasing use, particularly in European countries, of roller gates in positions where wide openings are necessary

and the construction of modified forms of the American bear-trap dam in some Continental rivers are also features to be noted in the reports from European countries. Practically all the reports afford evidence of the attention now being given to the provision of an adequate water cushion below a weir or gate and the form and dimensions of troughed aprons and dentated sills best adapted to prevent, or at any rate reduce, erosion of the river bed downstream of the apron of a barrage.

### United States of America.

One of the longest and perhaps the most detailed of the reports is that by Lieut.-Colonel E. L. Daley, Corps of Engineers, U.S. Army, and Mr. W. H. McAlpine, of the Chief-of-Engineers' Office, Washington (*Report No.* 45). The authors describe modern types of movable dams which have been built or are now being built as part of the vast canalisation projects for the improvement of the waterways of the Mississippi basin, now being carried out by the Federal Government. Particulars are also given of model experiments made at the hydraulic laboratory of the State University of Ohio to determine the best methods of protecting dams from undermining. The canalisation of the upper reaches of the Mississippi River itself is one of the most important of the projects already in hand. The river above Alton (Ill.) is being improved by locks and dams to provide a navigation channel of 9ft. minimum depth for a distance of 650 miles to Minneapolis, Minnesota. Thirteen locks and eight dams are now under construction, four locks and dams having already been completed, and others are soon to be begun.

Two general types of movable dams, navigable and non-navigable, have been used on the rivers of the Upper Mississippi basin. The type generally employed on the Ohio River is the navigable dam, which contains locks for the passage of navigation when the pools are maintained, and a navigable pass which permits navigation through the dam when the river flow is adequate. Where the principal problem encountered is the prevention of excessive flood damage, or where the duration of river flow for open navigation is short, or where the difference in pool levels is too great for the operation of a navigable pass, the non-navigable type of dam has been used, as on the Kanawha, Upper Mississippi, and the Illinois rivers. Navigable dams in the Mississippi basin area usually comprise Chanoine wickets in the navigable pass which can be lowered when the natural flow is adequate for open river navigation. Bear-trap weirs, with a discharge capacity large enough to raise the lower pool to a height which will permit the operation of the Chanoine wickets are also installed in each dam. The bear-traps also provide a means for close regulation of pool levels and passage of drift. The largest navigable dam in the United States, from the standpoint of total dam area, is that on the Ohio at Louisville (Ken.) (No. 41), which has a total area of 52,177 square feet. The largest typical Ohio River dam is, however, No. 52, at Brookport (Ill.), built in 1928. This contains no less than 1788 lineal feet of Chanoine weir and three bear-trap weirs, each 91ft. long. The greater part of the Chanoine weir has a height of 18·7ft. from the level of the sill to that of the normal upper pool. The bear-traps are 15ft. high and are the largest of this type in the States.

It is perhaps unnecessary to remind readers that the Chanoine wickets in the wide navigable passes of American dams, as well as the trestles and shutters of Boule weirs, are always operated from a manœuvre boat equipped with powerful machinery. The crews of these boats become very expert, and wickets from 16ft. to 20ft. in length are raised expeditiously under a head of 6ft., and the shorter weir wickets under greater differences in level.

Among the many types of non-navigable dams used in the United States are Tainter gates, roller gate dams, and vertical lift gates, as well as combinations of these types. The authors state that Tainter gate dams have proved the least expensive of the several types. Their use is limited, however, by the span length and by the height to which they can be raised. Where wide openings are desired and where the flood heights require the gates to be raised a great distance above pool level, roller gates and vertical lift gates are more suitable. The former are also particularly adapted to operate under severe ice conditions. The largest Tainter gates, measuring 40ft. in width by 30ft. in height, are now being constructed at dam No. 26 on the Mississippi at Alton (Ill.), where there will be thirty of these, in addition to three 80ft. roller gates; but on the Illinois River there are twenty-one Tainter gates, built in 1933–34, each 60ft. long, but of less height. The largest roller gates yet built in America are those in the Mississippi No. 15 dam at Rock Island (Ill.), built in 1934, where eleven gates, each 100ft. long and ranging in height from 21·75ft. to 26ft., have been installed. Submersible roller gates are now being installed in some of the Mississippi River dams. The arrangements for sealing provided in these gates are of novel design. The lower portion of the rack is curved to permit the gate to drop below the sill, and the apron and shape of the sill are so adjusted that the former will follow closely along the sill as the gate is lowered. Large roller gates are also in use on the Kanawha River, where two dams were completed in 1934 having rollers 100ft. by 26ft., and another is now being built. A new high-lift roller gate dam is planned for the Ohio River, just below the mouth of the Kanawha River, where eight roller gates, each 125ft. long and 30ft. overall in height, will be installed. The gate area in this dam will slightly exceed that of the roller gate on the Glommen River in Norway, viz., 45 m. by 6·5 m. At Montgomery Island on the Ohio River ten vertical lift gates, each 100ft. long by 16ft. high, are now being built to replace some of the low navigable dams in a steep reach of the river.

A noticeable feature of all recent dams built in the Mississippi basin is the provision of stilling basins or troughed aprons below the weir and various types of baffles and end sills, many of them of dentated form. The report includes a valuable section on scale model experiments, mainly carried out to elucidate the theory of hydraulic jump and to study the effect of various forms of stilling basins, aprons, end sills, and baffles. Tabular statements, containing very full particulars of the principal rivers in the Mississippi basin and of the dams constructed in them in recent years, together with typical drawings, are appended to the report, which forms a valuable summary of the vast works of river improvement now being carried out by the United States Federal Government.*

### Germany.

Herr Bank, of the Neckar Navigation, describes in *Report No.* 43 the various types of movable dam employed in recent river weir construction in Germany. He mentions that lifting gates with openings up to 42 m. wide are now being constructed, and describes the system of electrical heating employed at the Kachlet dam, at Passau, on the Danube, to prevent freezing at the gate seals, which has proved satisfactory, even in times of hard frost. The three lifting gates at Obernau on the Main have openings 35 m. wide and a closing depth of 5·5 m. The upper part of the gate is in the form of a flap, 1·5 m. in height, hinged at the bottom for the purpose of regulating the overflow. This arrangement appears to be very generally adopted in gates, including roller gates, of recent construction in Germany and other Continental countries. At the Ryburg-Schwörstadt dam on the Upper Rhine, built in 1930, there are four vertical lift double gates of 24 m. width, which is 1 m. less than that of the Kachlet gates, but the closing depth, 12·5 m., is greater. At Dorverden, on the Weser, two roller gates, with openings 41·7 m. wide, have been provided, the head of water being 6·45 m. The gate itself, which carries a bottom-hinged flap, is built in the form of a box girder specially designed to resist torsional stresses. In this gate lifting gear is provided at both ends. All the weir parts likely to be affected by ice to an extent which would interfere with working are electrically heated.

The roller weir at Ladenburg on the Neckar has the largest span hitherto built in Germany, viz., 45 m. clear opening, and a closing height of 4·5 m. The roller gate is of cylindrical form, and is operated from one end only. It has been in use since 1927 and has worked satisfactorily. Submersible roller gates are provided at five dams on the Main and Neckar. The longest is at Heidelberg, where there are three openings of 40 m. All these were built between 1924 and 1930. Three other weirs now being built in connection with the work of canalising the Main will have three submersible roller gates in each. Those at Griesheim, near Frankfurt, have 40 m. openings and a closing height of 6·22 m., and all are provided with a novel form of sill closure which appears to be similar to that recently introduced in the United States.

### Italy.

*Report No.* 47, by Signori Pallucchini and Bonamico, shows that there is still considerable variation in the types of movable dam selected for use on rivers in Italy. These include bear-traps, roller dams, segmental or sector dams, lifting gates, and falling weirs of the Chanoine type. The largest sector gates of recent construction appear to be those on the river Velino, for the Gallito power station, which have a clear span of 22 m., a height of 6 m., and are lowered below the sill when the waterway is to be opened. Many installations of automatic sector gates have recently been built in Italy for openings up to a maximum of 22·5 m. in length, and some, of less length, have a retaining height of 6 m. Automatic gates, working on horizontal hinges at sill level, are also used, the largest examples having a length of 17 m. and a retaining height of 3 m. Among roller dams may be mentioned that on the river Adige for the Milan Electrical Supply Company, which has a span of 30 m. and a height of 4·3 m. Another example is the dam on the Brembo, 32 m. long, but of less height, 3·5 m., than that on the Adige. A few bear-trap dams have been built during the past ten years. One at Crevola D'Ossola comprises two weirs, one of which is 22 m. long, retaining a height of 3·1 m.

### Holland.

*Report No.* 48 by Messrs. De Vries, Egelie, and Jansen is confined in the main to the canalisation of the Dutch Meuse. Since 1925 large weirs have been built at Sambeek, Grave, and Borgharen. The downstream dam at Lith, begun in 1934, is not yet completed. The earliest weirs on the canalised Meuse, built before 1925, usually comprise navigable passes of from 60 m. to 68 m. in width, with two regulating gates of 17 m. opening. The passes have Poirée trestles with steel panels and the regulating gates are of the Stoney type.

The weir at Grave, where a roadway crosses the river, was completed in 1928 and has one opening of 50 m. and another of 60 m. Both openings are closed by weirs formed of three superposed rows of steel panels, each 1·6 m. deep and 5·44 m. long, supported against structural steel frames suspended vertically from the bridge and hinged near the top, so that they are capable of being raised to a horizontal position under the bridge. These frames rest at the bottom against the sill. The closing panels can be lifted by means of a travelling winch. The weir at Borgharen, also completed in 1928, has a navigable pass of 30 m. width and three regulating openings, each 23 m. wide. Both the navigable pass and the regulating openings are closed by gates on wheels raised by electrical machinery in towers on the piers connected by an overbridge. The gates in the regulating openings are provided with hinged flaps above the main gate structure, the total retaining height being 4·5 m. At Lith the three openings of 38 m. are closed by roller gates, and, as at Borgharen, on the top of each gate is a hinged flap by means of which the water level in the upper reach can be regulated when it is not necessary to raise the gate. The total height of the gate above the sill is 7·25 m.

### Sweden.

Three separate papers came from Sweden—(*Report No.* 49). Messrs. Jansson and Wickert describe an interesting movable dam, which is about to be built at Stockholm for the regulation of Lake Mälaren, comprising a submersible Tainter gate, 44 m. wide and 5·5 m. deep. Mr. K. I. Karlsson deals with special types of movable dams which have been designed for use in Sweden, where the floating of lumber down the rivers is an important consideration. Among the systems of closure described are needle dams and sector gates. Of the latter type, gates up to 35 m. in width have been built; one, 7 m. deep, is now being constructed at the Krangede dam. The report contains interesting details of the provision made for the electrical heating of water sealing elements of gates. Mr. G. Von Stapelmohr, of the Royal Board of Waterfalls, Stockholm, describes the Tainter gates at the Vargön electric power station on the Göta River.

### Switzerland.

*Report No.* 50 is by Messieurs Buchi and Jenny, of Zürich. It contains a long and comprehensive account of the principal movable dams in navigable, or potentially navigable, waterways, built in Switzerland since 1912. The paper includes, in tabular form, particulars of all of these and a comprehensive series of drawings. A favourite type of dam on these rivers is the vertical lift gate, especially those comprising an upper gate and lower gate; but the authors point out that hydraulically controlled bear-trap weirs, such as those at Damsau and Interlaken, built in 1932 and 1933 respectively, are coming into favour. Hitherto roller gates have not been used in Switzerland. The authors mention that bear-trap weirs have been built at Zürich, by the firm of Huber and Lutz, for installation in other countries, some being of considerable size. One, erected at Tours-sur-Margne, near Epernay, is 34 m. long and has a retaining height of 2 m. Another, designed by this firm and now under construction in Indo-China, comprises seven openings of 33·7 m. each, having a maximum retaining height of 7 m., a greater height than any in the United States. One of the most interesting sections of this report is that devoted to the consideration of tests on scale models and the design of weir sills and aprons.

### Czechoslovakia.

Three papers come from Czechoslovakia (*Report No.* 51). Professor A. Smrcek, of Brünn, describes the model experiments which formed the basis for the design of the Waag barrage. Herr R. Drbohlav, of Prague, describes river barrages constructed in Czechoslovakia since 1914. A large number of these are of the Stoney gate type, having clear openings up to 25 m. in width and retaining heights up to 5·5 m. In situations where the height of water to be retained is considerable, superposed gates have been used. The Masaryk dam, on the Elbe, has four sluiceways, each having a clear span of 24 m. and a gate height of 10·9 m. Roller dams have also been used on Czechoslovakian rivers, the largest, brought into use in 1929, being at Oeské Budejovice, on the Vltava, where the clear span of each of the two openings is 28·5 m. and the height of the roller dam 3·55 m.

Dr. I. Smetana, of Prague, contributes a discussion on mathematical lines of problems related to the flow of water over weirs and through sluice openings. He describes model experiments carried out recently at the Masaryk Hydro-technical Institute at Prague, particularly in reference to theories of water jump,

* Lieut.-Colonel C. L. Hall, Corps of Engineers, U.S. Army, contributed to the proceedings of the Congress a paper on the second question in the Section of Inland Navigation, "Regulation of Canalised Rivers," which contains an account of the regulation of the Ohio River and the operation of its weirs. The Ohio is the longest fully canalised river in the world—981 miles. This is a particularly valuable paper because of its description of operation procedure. The author observes that no complete account of this problem, as it is presented on the Ohio River, has previously been published.

the dimensions of water cushions, and the most effective forms of sills and aprons.

FRANCE.

Monsieur J. Aubert is the author of the paper on French dams (*Report No.* 46). He describes typical river barrage works built in France and the French Colonies during the last ten years. Of the dams provided with lifting gates he includes those at Kembs on the Rhine and at Chatou and Suresnes on the Seine, all brought into use in 1932. Roller dams are represented by those at Argancy and Uckange on the river Moselle. Interesting examples of improved Chanoine-Pascaud wickets at Vives-Eaux on the Seine, the Meaux dam on the Marne, and in the navigable pass of the Suresnes barrage are described. A very large barrage of this type at Sansanding on the Niger River in the French Sudan, the construction of which was begun a year ago, is also mentioned.

In regards to dimensions, the lifting gates described by the author are very similar. At Kembs the five sluiceways have clear openings of 30 m. each. Chatou has three openings, each 30·5 m. and the one opening at Suresnes is the same width. The Kembs lifting gates are of the superposed type, the lower gate being of Stoney pattern, the upper of the truck type. The normal height of water retained is 11·5 m. above sill level. Erosion downstream of the apron occurred soon after the barrage was brought into operation and the construction of an extension of the apron in the form of a double layer of 5-ton concrete blocks became necessary. The Chatou barrage was also completed in 1932. The superposed gates are of the Stoney type, and have a total closure height of 7·72 m. At Suresnes the superposed gates are of truck type and the height of closure is 7 m. The two roller dams at Argancy were built when the Moselle was canalised and were brought into service in 1932. Each dam is composed of four cylinders, of which two can be lowered so that the upstream pond level can be regulated by allowing the water to overflow. At Argancy the length of the cylinders is 27·50 m.; at Uckange the four sluiceways are each 32 m. wide.

Although the earliest shutter or wicket weirs were constructed on the upper Seine and its tributaries over seventy years ago and the system has been widely employed on rivers in the United States, barrages of this type came to be considered out of date in Europe, and, according to Monsieur Aubert, for over forty years no example was built on the Continent until a few years ago when improved types of Chanoine weirs were constructed on the Seine. The first example of the revived Chanoine weir was built at Varennes in 1925–26. The more recent barrage built at Vives-Eaux in 1928–29, is, however, of greater interest. There is one river pier separating from each other two navigable passes, whose widths are 64·5 m. and 46·5 m. The shutters, each 5·2 m. high, are operated from an overbridge carrying an underhung-electric travelling winch which operates an articulated arm, by means of which the shutters are hooked and raised or lowered, as the case may be. The working is controlled by one man who is able to raise the shutters, of which there are seventy-four, at the rate of thirty per hour. The reverse operation is still more rapid. The navigable pass at Suresnes has a width of 72·4 m. and the shutters when raised stand at a height of 6·5 m. above the floor. The barrage on the Marne at Meaux, which is expected to be completed in 1936, is similar to that at Vives-Eaux, with the exception that the travelling winch for operation runs above the service bridge instead of being suspended beneath it.

The great barrage on the Niger, construction of which began a year ago, is intended for the irrigation of an area of about 2½ million acres, and comprises sixteen sluiceways, each 55 m. wide, water being retained at 5·6 m. above the sill level. The system adopted for this barrage is the Chanoine wicket and the shutters will be operated from a road bridge, which is to be built across the river at the site of the weir. As in the case of the Meaux bridge, the travelling winches, of which there are three, will be placed on the top of the bridge.

THE ARGENTINE REPUBLIC.

Professor R. E. Ballester, of Buenos Aires (*Report No.* 44), describes the reconstruction of the aprons of the barrage across the Neuquen River, in Argentina, where serious erosion and consequent partial failure had occurred. The original aprons were reconstructed with dentated sills of the Rehbock design, after model experiments had been carried out at the Karlsruhe hydraulic laboratory.

UNITED STATES OF SOVIET RUSSIA.

Two papers come from Russia (*Report No.* 52). Professor B. H. Gobel, of the Research Institute of Hydrotechnics, Leningrad, describes two large roller dams at Dsorages, Armenia, and at the hydro-electric power station at Doubass respectively, and the segmental gates of the Michailow dam on the river Moskau, now under construction. The Dsorages barrage has a clear opening of 24 m. and a retaining height of 6·5 m. Worked mechanically in normal conditions, it rises automatically under flood conditions without it being necessary to set in action the working mechanism. An automatic rise up to a free height of 3 m. is obtained by the rolling upwards on an inclined rack of the toothed terminal bearings of the cylinder, under the effect of the water pressure resulting from the evacuation of the flood discharge, partly over and partly underneath the closing structure. It is said that floods sometimes occur suddenly and without warning. The dam has been in operation since 1931.

The roller dam at the Kramatorschen Works (Doubass) has a clear opening of 34 m. and a retaining height of 4·8 m. The moving parts have a weight of 175 tons and the barrel consists of a tubular girder of the Linse type, with an approximately eliptical cross section.

The Michailov dam on the Moskava River is in the form of a segmental gate and closes an opening 33 m. wide, with a retaining height of 7 m. The gate body is formed of a tubular Linse girder of oval cross section. The rigidity against torsion of the tubular girder is sufficient to permit of the mechanical effort in raising and lowering the dam to be applied at one end only of the structure. The total weight of the movable parts is about 220 tons.

Professor N. N. Pavolvsky, of the Leningrad Institute of Hydrotechnics, contributes a mathematical paper on the design of weirs and sills with the object of reducing scour. He, like nearly all the authors of these communications, stresses the importance of model experiments in connection with the design of weir structures.

# Great Western Railway Centenary Banquet

ON August 31st, 1835, the Bill for the construction of the Great Western Railway received the Royal Assent. The company was incorporated and empowered to build a railway starting at Temple Mead, Bristol, passing through the counties of Gloucester, Somerset, Wiltshire, Berkshire, Oxfordshire, Buckinghamshire, and Middlesex, "terminating by a Junction with the London and Birmingham Railway in a certain Field lying between the Paddington Canal and the Turnpike Road leading from London to Harrow," and also branch lines. The first general meeting of the new company was held at the City of London Tavern on October 29th, 1835. Almost exactly one hundred years later, on Wednesday, October 30th, a great banquet was given by the company in Grosvenor House, Park-lane. The chairman of the Great Western was in the chair, and the principal guest was the Prince of Wales. The huge company, numbering well over twelve hundred persons, was principally composed of servants of the railway, but there were as well many eminent guests and many more of less eminence or of no eminence at all. To each guest was presented a printed souvenir volume of the Great Western, and to each a cardboard model of Gooch's famous 8ft. single-wheeler "Lord of the Isles," ingeniously devised to hold a cigar in the fire-box and a cigarette in the chimney. At the conclusion of the banquet, an historical and pictorial film of the Great Western Railway was exhibited in the dining hall.

The toast of the evening was very happily proposed by the Prince of Wales, and the response was made by Sir Robert Horne in the address which we print below.

GREAT WESTERN RAILWAY.

Amongst the many meritorious organisations which have owed much to your influence and support, your Royal Highness has for many years reserved your greatest enthusiasm for those which promote industry and create employment for the people. To-night, in the same tradition, you confer a high favour upon us and vicariously upon our predecessors who, through a century of history, have created and conducted a great and expanding industry, employing a vast number of people, in the discharge of a duty which we are proud to perform for the service of the country. That you have thought us worthy of this honour adds a Feather to our Cap—may I say a Prince of Wales' Feather?—and puts us under a lasting debt of obligation to your Royal Highness. In company with all who are assembled here, and with every man and woman in our service, we express to you our whole-hearted gratitude.

Your Royal Highness has spoken of the success which the Great Western Railway has achieved and the reputation which it holds amongst the people of England. We, of this day and generation, are proud of these results, which in the main we modestly admit are the products of past administration. *We* endeavour to maintain and perpetuate these traditions, and we have a great army of faithful men in our service who loyally support our efforts. It is our good fortune to have evoked amongst those who live upon our system something which approaches a sentiment of family affection. That in no way involves any diminution in their zest for admonition. Never in the history of time has "family affection" done that; rather does it tend to stimulate the spirit of correction. But it is done for our good, and we welcome it. Even if at times we may wilt under too harsh an expression of reproach we can always be comforted by listening to what our critic thinks of the other railways.

My Lords, Ladies and Gentlemen, the presence of the Prince of Wales to-night inevitably carries our minds back to the many journeys by members of the Royal House that have taken place between Windsor and Paddington, and, in particular, to the fact that the first—and, indeed, the last—journey which Queen Victoria ever made by rail was upon that route. The last was on a day in February, 1901—the day which brought to a close one of the most shining eras in history—to be known for ever afterwards by her name. The first was nearly sixty years earlier, on June 13th, 1842, when Her Majesty travelled in the first eight-wheeled railway coach in existence, and recorded at the time that "the journey had been accomplished free from dust and crowd and heat," and that she was quite charmed with it. With their customary curiosity, Members of the House of Commons did not fail to take notice of this journey. A question was asked in the House by an honourable member which seemed to imply that Her Majesty's person ought not to be subjected to the risks of railway travel, and an answer was given stating that two carriages had been interposed between the engine and the one occupied by the Queen, in order to obviate risk of collision. Doubtless it was this reply which inspired a well-known bishop to remark upon a certain occasion that he had a profound belief in Divine Providence Who over-ruled all things to His purposes, but he was always careful never to travel in the compartment next the engine.

Upon the occasion of that momentous journey, however, the Queen's safety was ensured by other more effective aids. Gooch himself—one of the greatest designers of railway locomotives of all time—drove the engine, and the illustrious Brunel was in the cabin. And there was another unusual, not to say strange, occupant of the footplate in the person of the Queen's favourite coachman, who insisted upon accompanying the engine-driver in order to see that nothing was done to endanger Her Majesty's safety. According to the contemporary narrative, when he descended to the platform in Paddington Station at the end of the journey, he much more resembled a dishevelled Christy minstrel than a servant in the Royal Livery.

A further episode connected with Queen Victoria may interest you. A new coach was built for her in 1850, more elaborate and more comfortable than anything that had been known in travelling equipment up to that time.

But the chief feature of this coach was the fact that it carried on the roof a signal of disc and cross-bar which was operated from within the coach by Her Majesty. She was able to indicate by this means whether she wished the train to stop or go faster or more slowly. As one would have supposed, the engine-driver might have been distracted between keeping a good look-out ahead and at the same time watching for Her Majesty's signals behind. But in order to set that matter right, a servant travelled upon the tender of the engine, seated under a hood, who was able to observe the Royal signals and establish communication with the engine-driver.

The question in the House of Commons, to which I have made reference, indicates something of the feeling of suspicion and distrust of railways which still existed at that period. These sentiments were expressed in more strident forms in the opposition which the promoters encountered to the construction of our railway. It is, indeed, in these days amusing and sometimes startling to observe the reasons which were put forward in some quarters against the passage of the incorporating Act.

A certain gentleman called Cort obtained considerable support, both moral and material, for views which he put forward in a book called "Rail-road Impositions Detected." One of his most ardent coadjutors and handsomest subscribers was the Provost of Eton, who feared the effect upon his pupils of a railway which might lure them to the Lights of London. Like Shakespeare, he must have thought, "How oft the sight of means to do ill deeds makes ill deeds done." And doubtless Brunel's 7ft. gauge suggested poignantly to his apprehensive mind the broad path leading to destruction. But there are some temptations that must be faced. In Scotland we have a phrase, "Them that wull to Cupar maun to Cupar," which, being freely interpreted, means that an Eton boy who has an assignation to attend the funeral of his grandmother at Kensal Green will take any means of transport for that purpose! At any rate, I shall not beg your sympathy for the members of the Great Western board on the ground that we toss sleepless on our beds for the part we have played in the demoralisation of Eton.

Cort, however, was a much more eloquent opponent

of the railway than even the Provost of Eton. With the prejudices which he entertained, it was not unnatural that he attributed these railway projects to "the speculation of engineers, attorneys, and capitalists," and he displayed a lively fancy in predicting that "people would be smothered in tunnels, while those that escaped suffocation would be burned." But he reached his most exuberant pitch in the following passage :—

> "Though the Great Western probably reach as far as Bath from Bristol, after having like a mole explored its way through tunnels long and deep, the shareholders who travel by it will be so deadly sick, what with foul air, smoke, and sulphur, that the very mention of a railway will be worse than ipecacuanha."

Recollections of a childhood clouded by frequent absorption of that nauseous emetic may bring home to some of us the effect upon Mr. Cort's readers of those doleful vaticinations.

In looking back to the year 1835, one is conscious of a vast difference in mental outlook as compared with 1935. A hundred years ago people were apprehensive and fearful of the results upon practical life of scientific ideas. To-day they are impatient of any seeming delay in applying them to conditions however refractory or unsuitable. It is the natural result of a century of unexampled progress in the application of scientific research to the common uses of mankind. Gone are the days when a Cambridge mathematician could say, "I have invented an ingenious and interesting theorem which never can be of any use to anybody for any purpose." To-day, every scientific theory is being turned to practical account. The treasures of the Realm of Pure Thought have been burgled a thousand times in recent years to serve the daily needs of modern life. The most startling feature of our time is, indeed, the rapidity with which practical invention has trodden on the heels of theory. All the more therefore must we acclaim our pioneers of a hundred years ago for the courage with which they countered the scepticism of their time.

The Great Western Railway is not to-day the same as any of them ever knew or imagined it. Expanded to three hundred times its original size—with its great accumulation of outside interests in the shape of steamers and omnibuses and aeroplanes and docks and hotels—it could not be recognised by any eye except that of faith. The company, however, is the same in character as it was a century ago. We are, I hope, as eager for new forms of reasonable adventure where these exist. We are ready, within our resources, to test new devices ; to adopt new methods ; to exploit the sea and the road and the air, as well as the permanent way of the rail. We confront, it is true, a new world in 1935, but we face it with the old spirit. And for inspiration, we are glad to recall that amid all the changes that have taken place the company's identity remains, its individuality is preserved, its vigour is undiminished, its traditions and reputation are high, and its place—pray heaven—in the loyalty of the people whom it serves securely established. I thank you all in the name of my colleagues and myself for the enthusiastic good wishes with which you help to launch our Argosy upon the Seas of our Second Century.

## AMERICAN FOUNDRY PROGRESS.

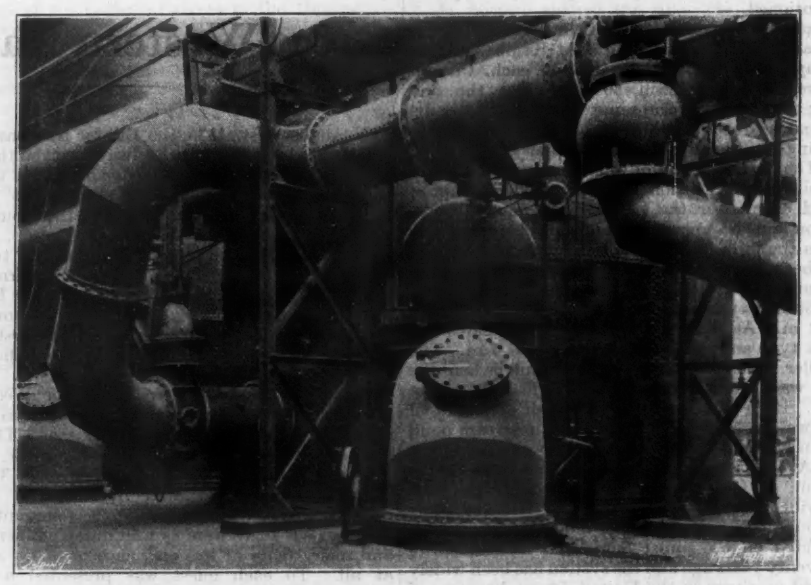
Problems and progress in steel, grey iron, and malleable iron castings were considered at the recent annual meeting of the American Foundrymen's Association. New combinations of steel castings welded to rolled steel plates and shapes indicate a field for co-operation between welding and casting interests. Since these interests are in competition, it is advisable for steel foundries to install adequate welding facilities, in order to manufacture products requiring a combination of cast and rolled material. In the United States Navy, a portable X-ray machine is used to inspect castings and discover defects, many of which can be rectified by cleaning and welding. While carbon in the lower 20's is generally desirable for work that is to be welded, foundrymen usually prefer 0·30 carbon as a minimum, but it should not be difficult to arrive at a compromise. Characteristics and temperature of the mould influence the time required for the metal to solidify, but the initial rate of skin formation can be reduced by pouring superheated steel. This rate increases with the surface area of the casting, but decreases with its volume. However, the factor of solidification is a constant. In grey iron castings, there is a wide use of compositions differing from what has been considered normal or orthodox. The tendency is towards irons low in carbon but high in tensile strength, which may be obtained by using a large proportion of steel scrap in the charge. Manipulation of the heat may be made as easy as in the electric furnace by means of the duplex system, in which a part of the charge is treated in a converter and added to the molten metal. Slag is a highly important factor. Acid-type slag promotes large austenite grains in the iron, and such iron has high strength. In the rotary pulverised coal furnace greater efficiency than that of a stationary furnace results by heating the metal from both the top and the bottom. The iron is stirred automatically as the furnace rotates, and with three tap holes there is no excessive wear of the lining at any one point while the furnace is being tapped. For economic use of continuous pouring, it is considered that the quantity should be at least 40 tons daily. Increasing attention is being given to the dust problem, as a health hazard. It is recognised that prevention of dust is preferable to dust collection. The shortage of skilled foundry labour is becoming apparent.

# Corby Iron and Steel Works.

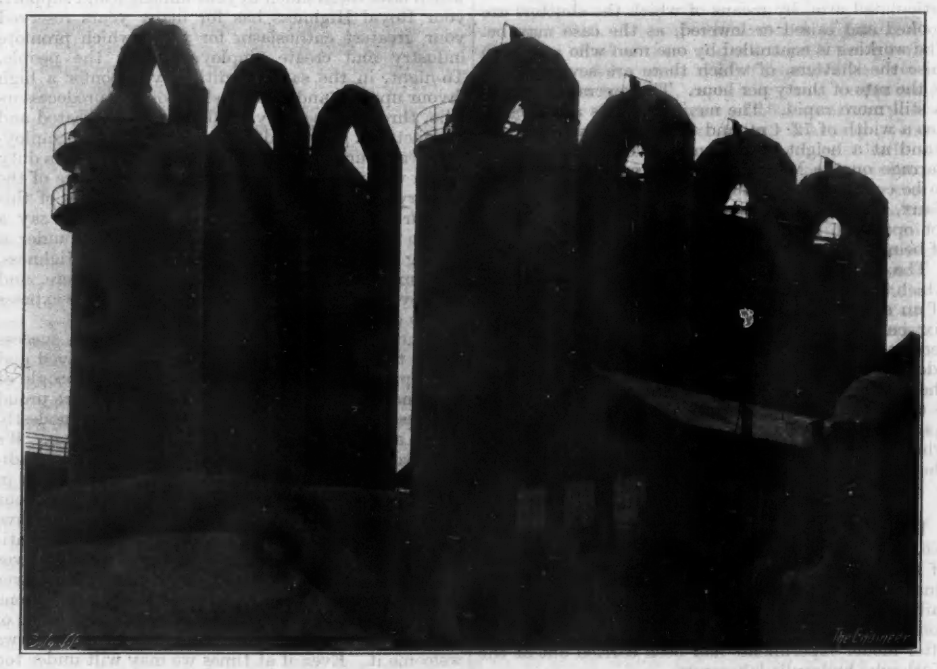
No. II.

(*Continued from page* 451, *November 1st.*)

IN our last article we dealt generally with the lay-out of the iron and steel works plant and the tube works, also the mining and preparation of the iron ore and its storage. We now pass to a more detailed consideration of the blast-furnaces and hot blast stoves, which were illustrated on pages 449 and 550 *ante*, and are shown in an engraving reproduced on page 482, which also gives a view of the ore-handling bridge, and the ore grab, with the furnaces in the background. On page 475 a view of the concrete-retaining wall of the ore storage yard, and the underside of the blast-furnace ore bins is given. The steel ore bins, we may state, were designed by H. A. Brassert and Co., Ltd., and were supplied by Sir William Arrol and Co., Ltd. Special attention may be called to the through-going road beneath the ore bins, which is used by motor cars and lorries when delivering material to the works. This particular construction is, we are informed, the only one of its kind, and it has certainly proved a great convenience to the works, while forming, as it does, a most interesting piece of pioneer engineering work.



Arrangement of Chimney and Gas Valves on Hot Blast Stove



Gas Cleaning Plant Showing Brassert Towers

### Blast-furnace Design.

The new blast-furnaces, which were shown on page 550 *ante*, have the following principal dimensions:

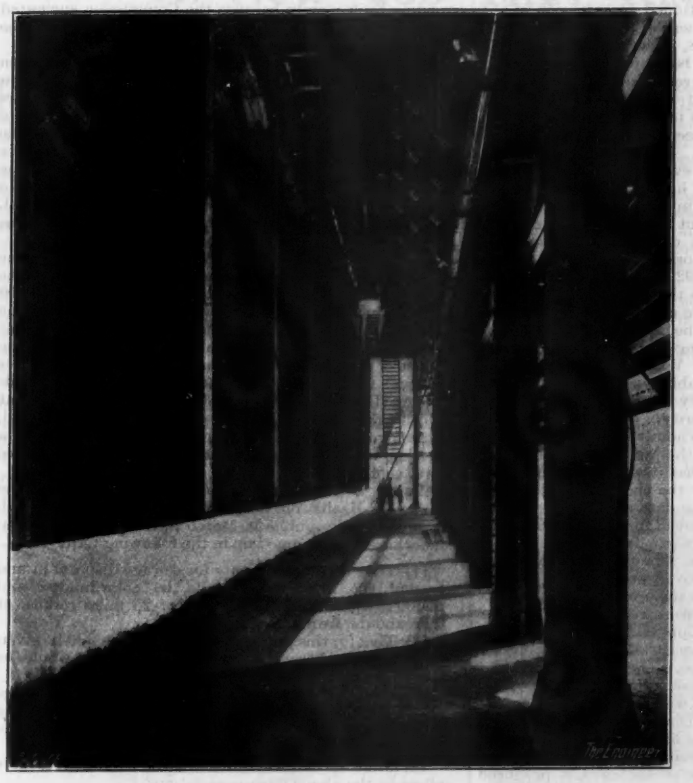
| | No. 1 furnace. | No. 2 furnace. | No. 3 furnace. |
|---|---|---|---|
| Height to top platform | 85ft. | 85ft. | 90ft. |
| Hearth diameter | 16ft. 6in. | 18ft. | 20ft. |
| Content, in cubic feet | 17,400 | 20,230 | 26,730 |

All the furnaces have fully developed Venturi inwall lines, which are designed to improve the distribution of gases and solids, and decrease the flue dust losses and permit the furnaces to be operated at a fast rate. They are the most modern blast-furnaces yet constructed, embodying as they do the latest Brassert design, incorporating the most recent practice on both sides of the Atlantic, and adapted to suit the special characteristics and smelting qualities of Northamptonshire ores.

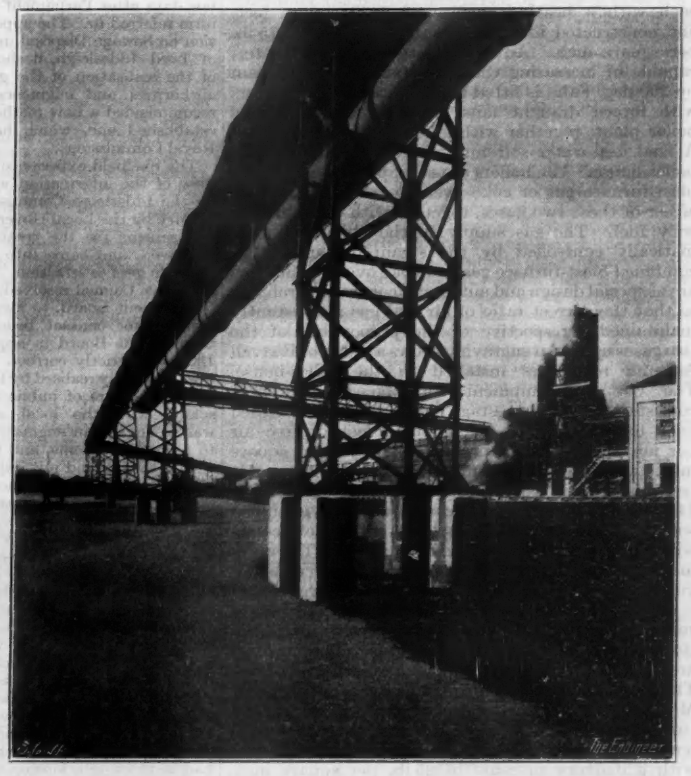
The No. 1 furnace was originally rated at 300 tons per day capacity, while the No. 2 furnace is rated at 350 tons, and the No. 3 furnace at 420 tons, with 29 to 31 per cent. metallic iron ore burden, over 60 per cent. of which passes through a 100-mesh sieve after it reaches the calcined state, the slag made per ton of iron being about 2400 lb. Even these capacities were based on an unusually rapid throughput of the burden. The production is, however, actually much greater, and in September it averaged 383 tons per day on No. 1 and 463 tons on No. 2 furnace. These figures are equal to rates of through-put of raw materials of 7·3 and 7 hours respectively, which must be considered a remarkable performance, taking into account the difficult nature of the carbonate ores and particularly their fineness, which renders even normal blowing very difficult. The whole of the steel work for the blast-furnaces and stoves was supplied by E. N. Wright, Ltd., of Wolverhampton.

The furnace hearth jackets are of the extra heavy plate and internal water-cooled cast iron type, and extend to considerable depth below the usual. The upper section of the hearth as well as the bosh and

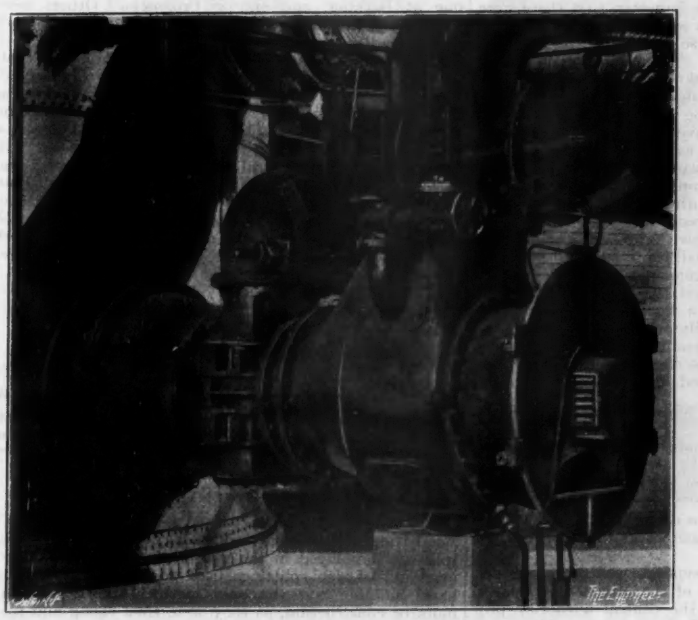
## CORBY IRON AND STEEL WORKS



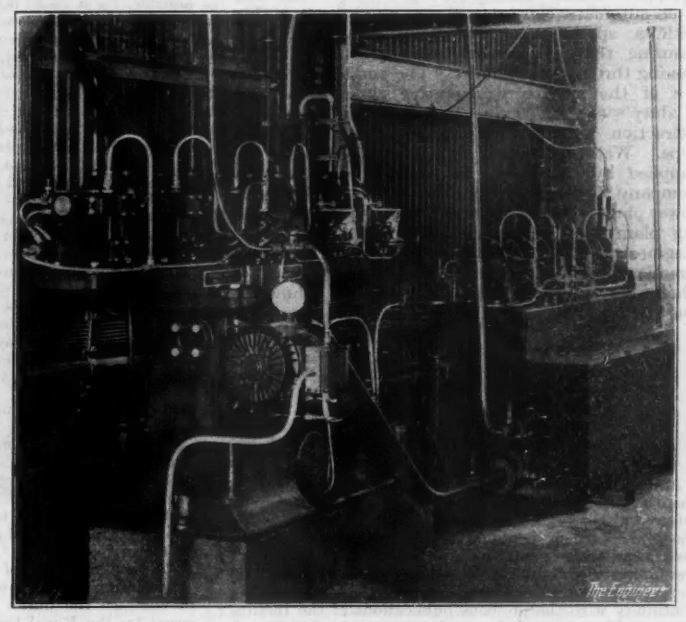
COVERED DRIVE-WAY UNDER ORE STORAGE BINS



BLAST-FURNACE AND COKE-OVEN GAS DISTRIBUTION MAINS



ONE OF THE HOT BLAST STOVE BURNERS



REAVELL-ASKANIA REGULATORS IN BOILER-HOUSE

lower inwall section of the stack are cooled with copper plates. In the upper inwall section is incorporated the new design embodying the Venturi lines. A special design of furnace top was employed to reduce the flue dust losses further, which it must be remembered is one of the main problems in working lean ores of the character of the Northants or Lincolnshire deposits, as well as the Minette ores of Luxembourg and Lorraine. The furnaces are equipped with an automatic rotating top distributor with revolving small bell hopper. The top structure of the blast-furnaces was supplied by Pearson and Knowles Engineering Company, Ltd., of Warrington. A double-skip hoist charges the furnace, fed by a self-weighing and registering scale car running underneath the furnace bins. Coke is fed into the skips from the coke bins by means of individual coke chutes at either side of the furnace skip inclines. The scale and transfer cars were built by Ashmore, Benson Pease and Co., Ltd., of Stockton-on-Tees. The pig casting machine working in connection with the blast-furnaces was built by Newton, Chambers and Co., Ltd., of Thorncliffe, near Sheffield, to Brassert design.

### Hot Blast Stoves.

The hot blast stoves are of the four-zoned regenerator type capable of supplying the maximum volume of wind required by the furnaces with a minimum of gas consumption at blast temperatures up to 1800 deg. Fah. With average blast heats, the gas consumption is 15 per cent. of the total blast-furnace gas production, leaving 85 per cent. less losses, for distribution to the coke ovens, the boiler plant, the sintering plant, the soaking pits, and the reheating furnaces. The zoning is carried out by means of special fillers of graduated shape, inserted into uniform checker openings. This arrangement equalises the gas and air velocities as between the top and bottom of the stoves, and thereby obtains a much greater efficiency from the lower sections of the brickwork. The fillers at the same time present horizontal surfaces to the gas and air, and, by the turbulence they cause greatly increase the rate of heat exchange by convection. There are no fillers in the top zone where heat transfer takes place by radiation, and where the velocities without the use of fillers are correct.

The stoves are equipped with a new design of automatically controlled stove burners, one of which is illustrated above, while another engraving shows the easy operating chimney valves and gas valves, which are specially designed to prevent leakage. The stove burners have the special feature of being rigidly connected to the stove casing, so that rapid stove changing is easily accomplished.

### Gas-cleaning Plant.

Owing to the dusty character of the Northants ore and the low specific gravity of the dust particles, the problem of cleaning the gas economically to the fine degree required by coke oven regenerators, soaking pit and reheating furnace regenerators and recuperators, required special consideration. A three-stage operation was adopted—firstly, a dry stage, consisting of large individual dust catchers at each furnace and a joint installation of small whirlers or vortexes; secondly, a group of multiple-stage Brassert tower washers; and, thirdly, an electro-static wet precipitation plant, which was constructed by Lodge-Cotteril, Ltd., of Birmingham. The whole gas-cleaning installation is under pressure from the furnace plant, which greatly increases the safety factor. A final gas cleanliness of under 0·01 grains per cubic foot is maintained. An engraving shows a view of the gas-cleaning plant. The clarification of the washing water is carried out by means of circular mechanical settling tanks with Dorr thickeners, The whole of the water required for cleaning operations is re-circulated. The clean blast-furnace gas is passed into a waterless gasholder of 2,000,000 cubic feet capacity, and distributed through the plant units under constant pressure conditions maintained by automatic control and a clean gas bleeder automatically controlled to keep the holder piston at any desired level. An engraving showing some of the gas distributor mains is reproduced above. The gasholders for the blast furnace and the coke oven gases are of the waterless type and were constructed by Clayton, Son and Co., Ltd., of Leeds.

### Boiler Power and Blowing Plants.

The blast-furnace boiler plant consists of a battery of four Babcock and Wilcox water-tube boilers, each with a heating surface of 6630 square feet, and constructed for a maximum pressure of 375 lb. per square inch. An integral type of superheater, capable of increasing the temperature of the steam by 200 deg. Fah., is fitted to each boiler. Air heaters with forced draught fans are incorporated in the boiler plant, together with gilled tube economisers. A final feed-water softening plant is installed in the boiler-house. The boilers are equipped for firing with blast-furnace gas or coke oven gas, or a mixture of either of these two gases, together with oil as emergency fuel. The gas supply to the boilers is automatically controlled by the steam demand. The combined blast-furnace gas and coke oven gas burners are of special design and automatic control is arranged, so that the correct ratio of air and gas is constantly maintained, irrespective of the proportions of the two gases used. An engraving shows a group of Reavell Askania regulators installed in the boiler-house. The blowing equipment for the blast-furnaces consists of two three-stage turbo-blowers designed for a normal duty of 36,000 cubic feet of free air per minute, against a pressure of 20 lb. per square inch, with a maximum duty of 40,000 cubic feet of free air per minute against a pressure of 14 lb. per square inch. These blowers are equipped with surface type condensers, each capable of dealing with 32,200 lb. of exhaust steam per hour. The automatic control equipment consists of a special constant volume regulator, together with two further regulators —one for anti-surging and the other for ensuring a constant weight of oxygen—irrespective of variations in the atmospheric conditions. The turbines are fitted with the latest type of auxiliary equipment. They are of the latest Fraser and Chalmers type, with Mirrlees Watson surface condensers. Two further turbo-blowers have also been installed, each having a maximum duty of 50,000 cubic feet of air per minute with a delivery pressure of 25 lb. per square inch, by Richardsons, Westgarth Brown-Boveri, Ltd., of West Hartlepool. These blowers are also equipped with automatic regulation, consisting of an automatic constant volume regulator, together with a special air flow gauge and calculator ensuring that a constant quantity of dry air is passing through the blowers. The condensing plants are of the surface regenerative type, each with a duty of 34,000 lb. per hour and an air-extraction apparatus of the two-stage steam jet type. Water-softening plant is installed and was supplied by the Becco Engineering and Chemical Company, Ltd., of London; while the water-cooling tower plant working in connection with the condensing plant was jointly supplied by the Davenport Engineering Company, Ltd., of Bradford, and the Premier Cooler and Engineering Company, Ltd., of Shalford, near Guildford, Surrey. We show on page 482 a view of the water tower and reservoirs.

*(To be continued.)*

## Sewage Disposal.*

By JOHN DUNCAN WATSON.

Mr. John D. Watson, in his Presidential Address to the Institution of Civil Engineers, on November 5th, briefly referred at the beginning to recent changes introduced by the Council, which should go far to encourage a more comprehensive outlook and create a better understanding of the interests pertaining to all engineers. These included the introduction of a Journal, which, while maintaining continuity with the previous publications of the Institution, would enable members to keep more closely in touch with the work which was being done to promote the science and practice of engineering. He then dealt with the phases of public works which had engaged his attention for more than half a century, and showed how the development of sanitation and improved water supplies had brought about a very considerable reduction in the death-rate. After giving examples of what had happened in some towns before and after the installation of up-to-date methods, he quoted figures showing that the annual revenue expenditure on sewerage, sewage disposal and water supply by local authorities in England and Wales had increased from £4,359,295 in 1885 to £30,735,274 in 1933.

He spoke of the Iddlesleigh Commission, whose reports showed that the disposal of sewage into an adequate volume of clean water—either salt or fresh—was sound and proper, not only on the grounds of efficiency and economy, but on strictly scientific principles. The advantages of multiple outlets to ensure quick and effective dispersion were pointed out, although where tides and currents existed near the outfall such quick mixing by multiple outlets might not be needed. It certainly contributed in all circumstances to the fulfilment of a sound principle.

Owing, however, to reductions in the volume of diluent water in certain cases and the necessity of having to discharge sewage effluents into comparatively pure water which might be required for drinking purposes, other systems of sewage disposal had to be adopted, and Mr. Watson referred to the opinion expressed in the past by Royal Commission after Royal Commission that the only way to purify sewage was to irrigate land with it, the famous Craigentinny Meadows having shown the way to do so economically. The history of how Birmingham solved its problems when it became a closeted town in the 'eighties and later laid out what proved to be the largest sewage farm in England for the treatment of sewage was then given. This practice was followed by the adoption of bacteria beds in the early days of the century, only a few days after Parliament sanctioned an extension of the farm referred to. The appointment of the Royal Commission on Sewage Disposal in 1898, under the Chairmanship of Lord Iddesleigh, it should be noted, was the result of the realisation of the great responsibility which local authorities and engineers had to assume when they recommended a new method to take the place of an old-established one, which had been approved by several Royal Commissions.

The Sheffield experience was even more noteworthy, in view of the information which had been made available by the Iddesleigh Commission in the interval. After an inquiry by the Local Government Board in 1905 a contact bed scheme for the treatment of Sheffield sewage was approved, and came into full operation in 1914, but it failed to give satisfaction. In 1922, only eight years later, the Town Council resolved, with the approval of the Local Government Board, to incur the cost of substituting bio-aeration for contact beds. The attitude of the Local Government Board in approving the original scheme in 1905 was strictly correct. Mr. Watson emphasised that it was not fully realised by the public that the responsibility for expenditure of public money rested primarily, if not solely, with the local authority, whose business it was to engage an engineer in whom they had confidence to prepare a scheme, and that the Ministry's approval of such a scheme did not imply that it was regarded as the best that could be designed, or the cheapest, or that the scheme embraced the most up-to-date methods.

As a matter of principle, purification by land irrigation was sound and still fairly popular. It had been carried on for more than 200 years at Craigentinny Meadows, Edinburgh, and was still employed at Paris and Berlin. When the soil was suitable and the area adequate, it was safe to say that the effluents from it in normal weather would be fit to enter a river. Contact beds followed land irrigation and possessed the merit of concentrating an unpopular work on a small area. They still existed and continued to perform the work for which they were designed, but they lost favour with the public when the Royal Commission on Sewage Disposal pronounced them less economical than percolating filters. Such filters were distinctly popular, and while that method of purification had a direct relationship to the contact bed, it produced a more consistently uniform effluent, was more generally reliable, and the operating costs were less. It was, however, advisable to locate filters as far from dwelling-houses as possible, for it could not be forgotten that there were recurring periods of close warm weather when fly nuisance and nauseating odours become so oppressive that residents in the locality complained.

Although it was almost unknown twenty years ago, bio-aeration or activated sludge was now established beyond question as one of the most useful methods of sewage purification. It had proved itself to be scientifically sound, and, when the plant was well designed, it was economical and freer from nuisance than any method yet discovered. It attempted to concentrate the process into the smallest possible space by bringing the sewage, gelatinous growth, and the air into more intimate contact than was possible by any other known process of purification. At the same time, however, small plants were too sensitive to be reliable where the management was unskilled.

Modern development showed that the chief element which made for progress in a democratic country was public opinion, and that usually concentrated upon what was desirable and what was readily obtainable at reasonable cost. In terms of sewage disposal, development on the following lines was indicated:—

(1) The adoption of more hygienic methods of sludge disposal.

(2) The adoption of methods to obviate smell and fly nuisance.

(3) The adoption of more reasonable treatment of storm water.

(4) Co-ordination of urban districts in watersheds to minimise the number of sewage works and improve their character.

(5) Establishment of a separate central authority, or extension of the powers of the Minister of Health, to embrace the duties of the central authority proposed by the Royal Commission on Sewage Disposal, 1898.

While there had been certain advantages in slow development, the sludge purification problem had for some years past been comparatively neglected, and the benefits of digestion had been underrated.

Although ability to free sewage from smell was not put forward as one of the benefits accruing from bio-aeration when the activated sludge method of purifying sewage was being lauded between 1915 and 1920, yet, after twelve years' experience it was safe to say that the bio-flocculation process hardly ever failed to remove all smell from sewage. Incidentally, this could be done practically without cost where bacteria beds were employed to effect nitrification, owing to the fact that the bacteria bed was capable of purifying double its normal volume of liquid when the sewage was devoid of colloidal matter.

That local authorities should incur the expense of purifying the whole flow of sewage in dry weather was accepted by everyone, and most people admitted that three times that volume should be treated in like manner in time of rain, but how much more ought to be treated when rainfall was excessive was open to question. Too little attention was given to the Ministry of Health's declaration that "in the absence of any special circumstance, overflow weirs should be fixed so as not to come into operation until the flow exceeds six times the dry-weather flow." County Councils, who were the rivers authorities in the great majority of cases, rarely troubled themselves about it, and the Ministry took no steps to see that their views were enforced.

The least costly item in building purification works was the construction of impounding tanks. Yet there was a tendency to make storm water tanks too small. While the suggestion of the Royal Commission that storm water tanks should be capable of holding six hours' normal dry-weather flow might have been adequate when it was put forward, the position was different to-day, as roads and backyards had been made more or less impervious. No authority was now justified in curtailing the size or limiting the efficiency of a storm water impounding tank merely because the Commission suggested when circumstances were different that its size might be limited to a six-hour capacity.

The loss resulting from lack of co-ordination was then dealt with, and as an example reference was made to a speech by the Earl of Derby at Manchester some years ago, when he pointed out that within a 15-mile radius of Manchester Town Hall there were no fewer than fifty-one local authorities or companies supplying gas, thirty-five supplying water, thirty supplying electricity, twenty-nine providing trams and omnibus services, and no fewer than one hundred controlling sewerage and sewage disposal. Since then many changes had been made, but there was still room for considerable improvement.

Mr. Watson mentioned the statement made by the Minister of Health, in supporting the third reading of the Middlesex Act, 1931, when he said: "This is a £5,250,000 scheme, which has resulted from proposals made by the Government to local authorities last year." In other words, the Minister looked upon the Middlesex Act as the outcome of a suggestion that local authorities might, under the Local Government Act, 1930, call County Councils to their aid rather than set up a new *ad hoc* body like that at Birmingham. That suggestion was helpful; it should, however, go further than call upon one county, because a watershed suitable for a joint scheme might embrace several counties.

Reference was then made to the recent report of the Minister of Health on Greater London Drainage, which was issued to the public in March last. Here the recommendations were summed up in the following terms:—

(1) That all arrangements for sewage disposal in and around the Metropolis should be co-ordinated and planned with regard to an area of 25 miles radius, or thereabouts, from Charing Cross.

(2) That for this purpose consideration should be given to a scheme whereby the whole of this area would be served by ten or fewer centralised disposal works.

(3) That within this area all further main sewerage and sewage disposal works, or extensions of existing works, should be designed so as to conform with the foregoing.

(4) That special measures should be taken to give effect to the above recommendations.

Of the ten purification works suggested, three were already in being—one at Heston and Isleworth, Middlesex, one at Barking, and one at Crossness. Others were receiving consideration from members of County and Town Councils adjacent to the Metropolis.

Mr. Watson concluded his address by pointing out that, while the nation owed a great deal to the Ministry of Health and to their engineers, there was still much to be done before the goal was reached when there would be no river pollution. It was obviously impossible to frame a standard of purity that would apply to all cases. His opinion was that a central authority was necessary, and that this should be the Ministry of Health rather than the *ad hoc* body suggested by the Royal Commission, provided that sufficient power was given to set up a Research Department wide enough to include the excellent work which had been done in recent years by the Water Pollution Research Board.

* The Institution of Civil Engineers. Abstract of Presidential Address, November 5th, 1935.

## BRITISH STANDARDS INSTITUTION.

*All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.*

### MICANITE FOR COMMUTATOR SEPARATORS.

No. 626—1935. During recent years there has been a steady and appreciable reduction in the size of mica splittings employed in the manufacture of all classes of micanite. Large splittings used to be employed when hand building was the only method known for commutator construction, as they were then cheap and easy to handle. These large splittings, however, are now much more expensive, and automatic methods of manufacture facilitate the use of smaller splittings. In order to safeguard the purchaser from having micanite built from very small splittings considerable research has been carried out by the Electrical Research Association, and this new specification has been based on the results of that work. It is laid down in the specification that not less than a given proportion of the splittings in a sample of stated size shall have a rectangular area of $\frac{1}{4}$ square inch or over, this figure taking account of breakages during manufacture, &c. This limitation, together with a stability (tendency to slippage) test under heat and pressure and an electric strength test (hot), should ensure a commutator micanite of satisfactory commercial quality, although admittedly not the best that can be made.

A recent issue of the *Chemical Trade Journal* describes a freezing process for cleaning greasy wools which has been developed in the United States. In this process the raw wool is subjected to a temperature of about —34 deg. Cent., whereby the grease is frozen. The wool is treated next in a dusting machine, which converts the brittle grease into a fine dry powder, while at the same time the hold of the fibres on the burrs, &c., is released. Foreign matter, including burrs, may thus be separated readily from the wool. The small amount of residual vegetable matter is usually detached from the fibre, during subsequent carding, &c., operations. A cleaning machine designed to carry out the freezing method has a capacity of 1000 lb. to 1500 lb. of the normal grades of wool per hour. Dyeing tests have shown that there is no material difference in the untreated and frosted wools, although in some cases deeper, brighter, and clearer colours are obtained in the latter case.

# A New 260 H.P. Railcar.

IT is now just two years since there was first produced by Hardy Motors, Ltd., of Southall, the 130 h.p. oil engine driven railcar, which we described and illustrated in our issue of October 27th, 1933. That railcar was exhibited at the last Commercial Motor Transport Exhibition, and later entered service on the Great Western Railway. That it was successful in service is demonstrated by the fact that the railway company has since purchased six more of a similar type with twin engines, and that a further ten are now under construction. But the firm has not rested on its laurels. There has now been constructed at the Southall works a new railcar exhibiting many alterations of design from its prototype. Its chassis is shown on the stand of Hardy Motors, Ltd., at the present Commercial Motor Transport Exhibition, and we learn that it has been purchased by the Great Western Railway Company.

It would be too much to expect that every detail of the first railcar produced by the firm should be entirely successful. In fact, it is common knowledge that certain small "teething" troubles developed in this car, and that when they had been rectified the experience gained was incorporated in the design of the railcars with two 130 h.p. engines constructed later. Reference to these modifications of design was made in an article appearing in our issue of June 29th, 1934. Further experience has now led

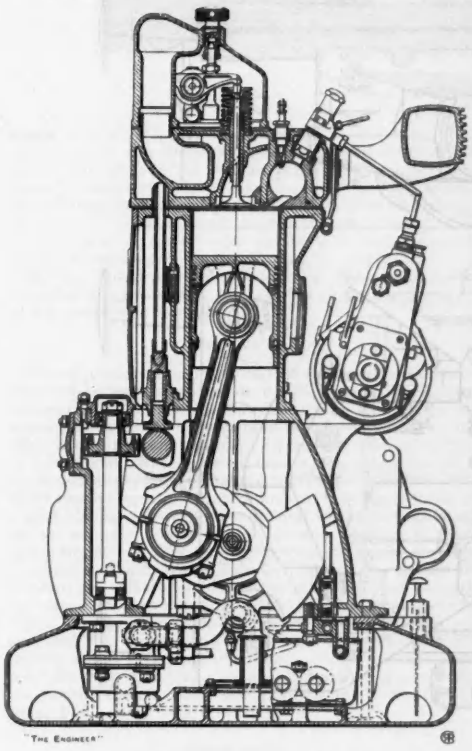


FIG. 1—SECTION THROUGH OIL ENGINE

the firm to believe that certain refinements in the design of the first railcars are unnecessary in railway operation, while others absent in the first cars, although not essential, are desirable. Moreover, the first railcar was designed for one engine and the incorporation of two engines and the resulting duplication of certain controls and mechanisms caused a complication of the connections from the control desk to the units. By redesigning, this complication was susceptible to correction. The changes which have been made may conveniently be enumerated shortly here before a full description of the new chassis is entered upon. The most obvious change—see Fig. 2—is that the main frame has now been designed to accommodate standard buffers and draw gear. In addition, the engines have been redesigned to reduce their height, the reverse gear-box has been removed in favour of a different arrangement, five forward speeds are made available instead of four, the engines are placed directly opposite one another on each side of the frame, the position of the radiators has been altered, bogie centres have been increased to give easier riding, and pneumatic controls and vacuum brakes have been adopted.

On a recent visit to the works we were given the opportunity to inspect the chassis, and were much impressed by the fact that the design had been made much "cleaner." It was also apparent that the firm was laying less stress upon keeping down the weight for, without any increase of power, the chassis had been lengthened and the bogie wheelbase increased. It was, however, pointed out to us that the only advantage of light weight was that high acceleration could be obtained and that an alternative means of reaching the same desideratum was to lower the gear ratio. Thereby it is true the top speed is affected, but it must be remembered that high acceleration is only of appreciable value in a local service with frequent stops in which the attainment of high speeds is rarely possible. An increase of weight has the advantages, to set against this loss of acceleration, of superior strength to withstand shunting shocks and the stresses set up if a trailer is drawn, and that it adds to ease of riding, and therefore to the comfort of the passengers. The exact design of the body which is to be fitted to the chassis has not been finally decided upon. The drawing on page 478 shows a design which has been suggested for a car not required to run at high speeds. It will be seen that the full streamlined design has been departed from in favour of a coach with rounded ends. Shrouding is carried almost to rail level along the central part of the body, but the bogies are not so covered. If a car with this design enters service, it will be interesting to compare its performance with that of its predecessors, so that the influence of streamlining on speed and fuel consumption can be assessed. In this connection it may be worth while quoting figures given to us by the firm, which show that the average fuel consumption of the twin-engined streamlined cars at present in service has been 7½ to 8 m.p.g., inclusive of shunting, and that the running costs, including interest, depreciation, wages, fuel, lubrication, and maintenance charges, have averaged 7½d. to 8d. per mile.

### CHASSIS.

A general arrangement drawing of the complete chassis is reproduced on page 478, in connection with which it is desirable to mention that the railcar is symmetrical about

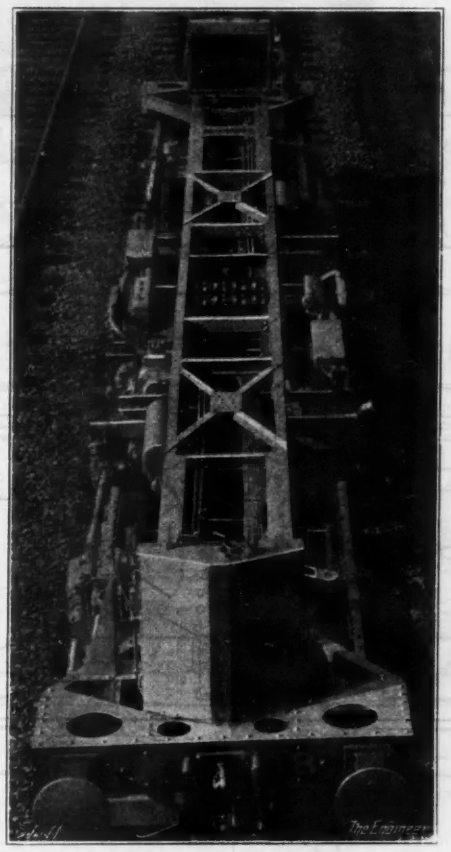


FIG. 2—GENERAL VIEW OF CHASSIS

its two centre lines, so that the bogies are identical. The main dimensions are given in the following table:—

| | |
|---|---|
| Length over headstocks | 62ft. |
| Length over buffers | 65ft. 8in. |
| Bogie centres | 43ft. 6in. |
| Bogie wheelbase | 8ft. 6in. |
| Frame width | 3ft. 2in. |
| Frame height above rail | 3ft. 11in. |
| Overall width | 8ft. |
| Wheel diameter | 3ft. 1in. |

The main side members and buffer beams are 12in. by 3½in. channel section. Reinforcing members are riveted on the inside of the main side members above the bogies in order that the car may be lifted from the buffer beams, if required. The comparatively narrow frame width is adopted, of course, in order that the driving units, &c., can be placed in accessible positions outside the frame. Those interested in the arrangement of structures will observe that all the cantilever members are straight, and that the units carried are so placed that a cantilever on one side of the frame is always "balanced" by a cantilever on the other side. The bogies are of the swing link bolster type. The main bearing springs are 4ft. 8in. long by 3½in. wide, while the bolsters are carried on nests of three concentric springs. The bolsters are fitted with centering springs and the plungers for the latter have large heads, which bear against strips of bonded asbestos attached to the sole bars, thus providing shock absorbers for the vertical movement. Sand-boxes with valves of the Westinghouse ejector type are carried on the bogies.

### GENERAL ARRANGEMENT.

The general arrangement of the units on the frame and of the drive to the axles is similar to that of the twin-engined car we described in our issue of June 29th, 1934. But, owing partly to the increase of the bogie centres distance, and partly to the elimination of the reverse gear-box, it has been made possible to place the two engines exactly opposite one another, one on each side of the frame. Actually, with the object of preventing engine vibrations being transmitted to the frame, the two engines are mounted in an independent sub-frame, consisting of two cross members joined up by two longitudinals and gusseted together. This sub-frame is suspended from the main frame side members through rubber blocks. Sideways and endwise thrust, as well as any upward reaction, is resisted through the same medium and the resistance to the last-named is made adjustable. It is interesting to note that being opposite one another and, as viewed from one end of the car, rotating in opposite directions, the torque reactions of the engines balance out. The weight of the batteries, which are mounted on the sub-frame,

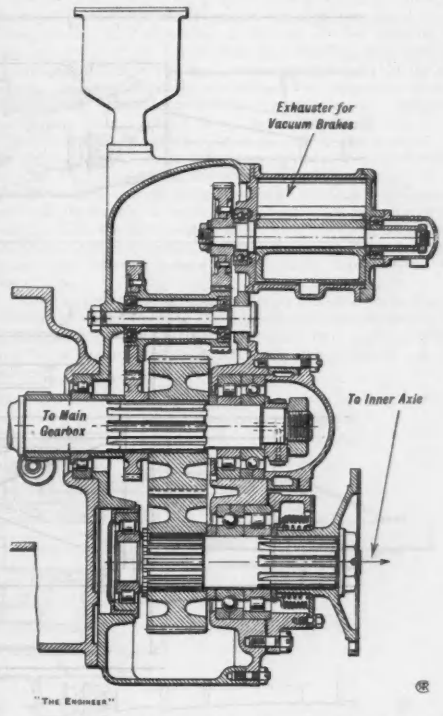



FIG. 3—CHANGE-GEAR REDUCTION GEAR ASSEMBLY

further increases its inertia, and thereby reduces vibration to an even lower degree. The engines are each attached to the sub-frame by a bell housing at the rear and a hanger with a Silentbloc bush at the front end. The situation of other units on the sides of the frame, such as fuel tanks, air reservoirs and other auxiliary equipment, will be clearly observed in the drawing on page 478 and the tone engraving, Fig. 2. Like the engines, the gear-boxes, too, are suspended through thick rubber pads in order to prevent noise and vibration being transmitted to the main frame. It will be observed that the chassis is truly symmetrical cornerwise. Standing at either end of the chassis and looking along it, the engine on the left drives the axles of the nearer bogie and the engine on the right the axles of the distant bogie. The two transmission systems are identical in design and arrangement. As in previous designs, the drive is taken from the engines through fluid fly-wheels to Wilson preselective gear-boxes, and thence *viâ* flexible telescopic propeller shafts to both axles of each bogie.

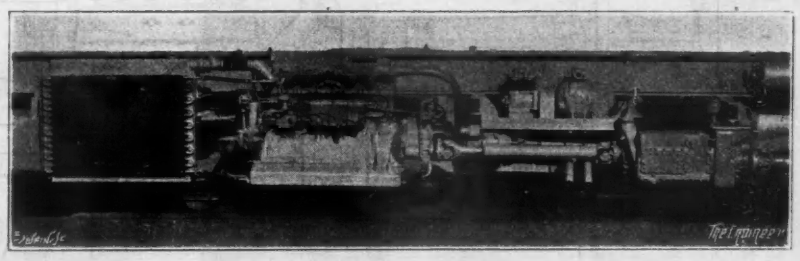


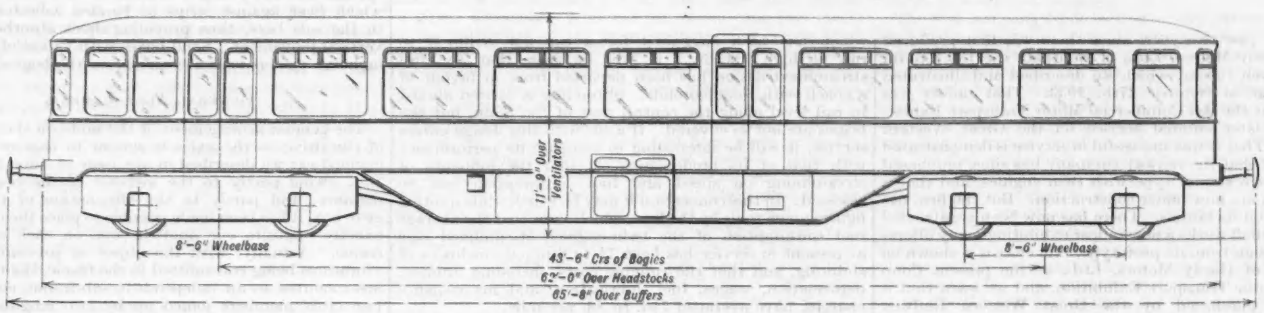
FIG. 4—SITUATIONS OF RADIATOR, ENGINE AND GEAR-BOX

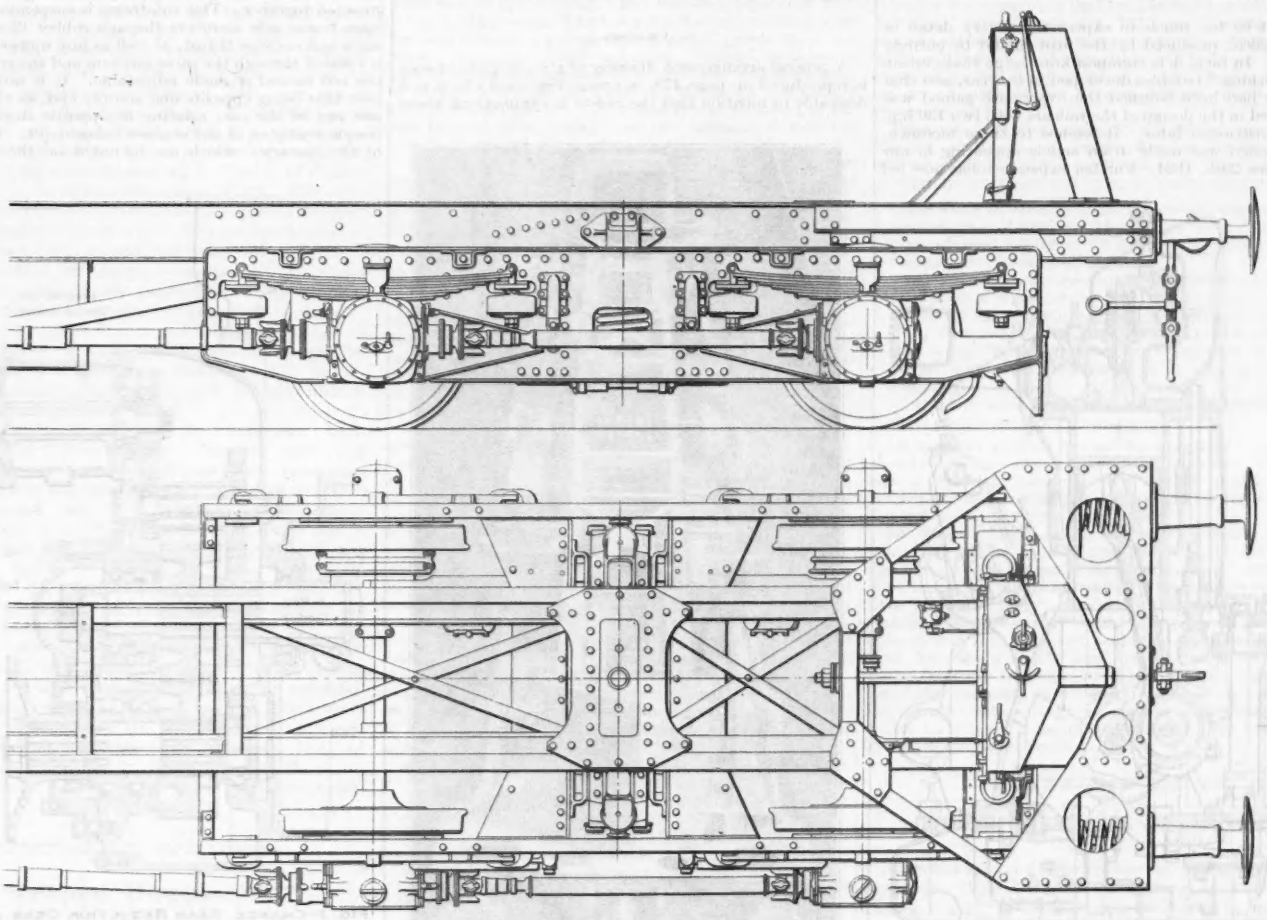
### ENGINES.

Each of the engines is a six-cylinder A.E.C.-Ricardo, with a bore and stroke of 115 mm. by 142 mm., developing 130 b.h.p., and having a speed range from 600 to 2000 r.p.m. The normal design of this engine has been modified for

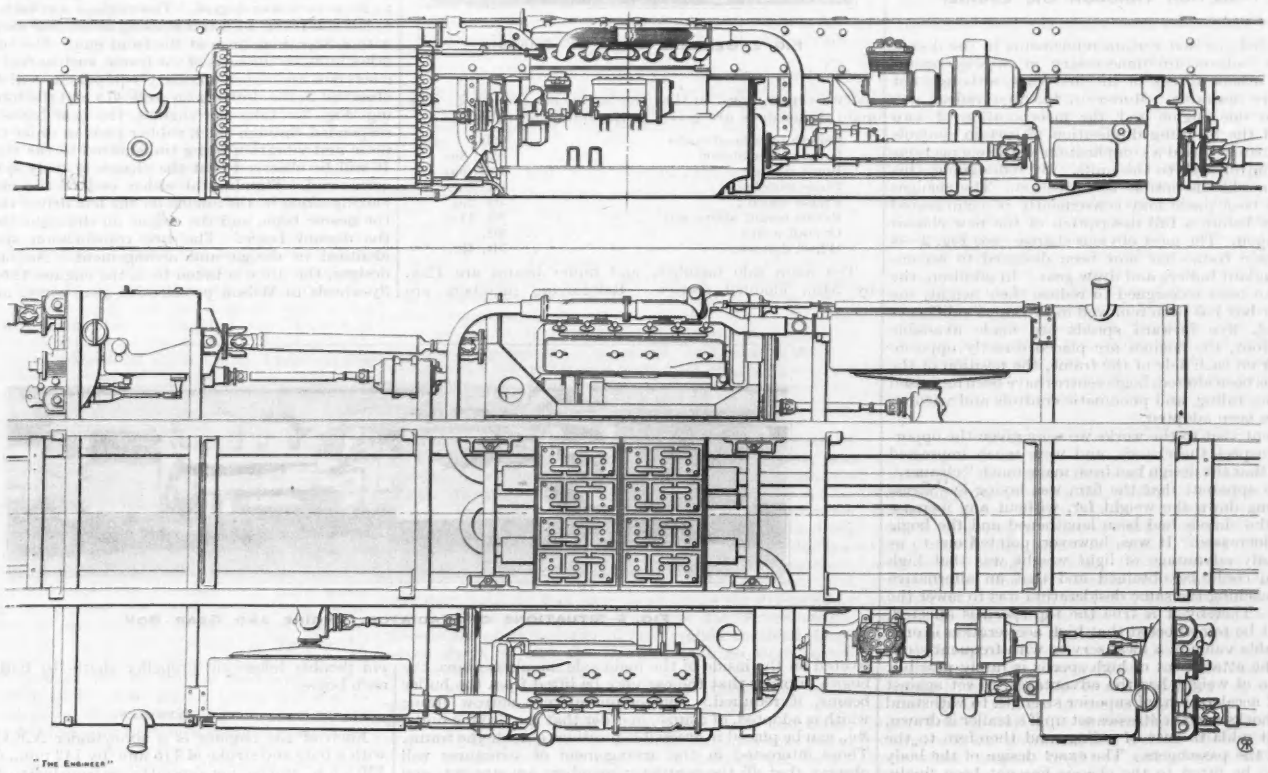
# NEW 260 H.P. OIL ENGINE DRIVEN RAILCAR

HARDY MOTORS LTD., SOUTHALL, MIDDLESEX, ENGINEERS



BOGIE. ELEVATION AND PLAN



"THE ENGINEER"

POWER UNITS, ELEVATION AND PLAN

use in the railcar with the object of reducing the height necessary to accommodate it. No part of it now projects above the level of the main frame of the chassis, so that there is a consequent simplification of body design. This result has been achieved by adopting a system of dry sump lubrication. It will be observed from the drawing, Fig. 1, that the sump is divided longitudinally into three compartments, the outer two of which are, in fact, connected together at each end. Oil splashed from the bearings and the relief valve falls on to a grid of "Still" tubes, through which cooling water is caused to flow, and thence passes *vid* a gauze filter into a space below. It is withdrawn from this point by the first stage of a two-stage lubricating pump and removed to the outer compartments of the sump, whence the second stage of the pump delivers it to the wearing parts of the engine. The pump is designed to be of such capacity that the central space is kept nearly empty of oil. Thus a large oil capacity is obtained in the outer compartments without submerging the oil cooler tubes in the inner compartment, which, if submerged by the oil, might "sludge up."

An air compressor lubricated from the crank case is mounted on each engine, and supplies air for the operation of the pneumatic controls.

### Radiators.

In the previous railcars, it may be recalled, the radiators were set askew to the engines. Two louvred panels with blades curved in opposite directions were situated in the side of the car and a baffle behind them brought one or the other into operation according to the direction of motion of the vehicle. In the present design this system has been discarded, as experiment has proved that a simpler arrangement can be equally effective and is more susceptible to a neat placing. As will be seen from Fig. 4, the radiators are set at right angles to the ordinary position in front of the engine. A 32in. fan driven from the engine through a propeller shaft, bevel gearing, and a belt, draws air through the radiator, and delivers it to the space beneath the car. Each radiator is of the vertical "Still" tube type. On the outer side a number of similar tubes are arranged "in series," and act as the radiator for the oil-cooling water. Whereas, of course, a relatively small temperature drop of a large volume of water is required by the engine, the oil cooler needs only a small quantity of water but a large temperature drop.

### Gear-boxes.

Like those on previous Hardy railcars, the gear-boxes are of the Wilson preselective epicyclic type, the general design of which has been described in THE ENGINEER on more than one occasion. Each box provides five alternative forward speeds, with ratios of 1 : 1, 1·64 : 1, 2·53 : 1, 4·5 : 1, and 6·38 : 1. Each gear-box is lubricated from two excentric pumps, one driven by the input and the other by the output shaft. At the front end of the box a chain transmits a drive to a lay shaft, which, in turn, drives a dynamo through a universally jointed shaft. At the rear end of the box there is a reduction gear assembly so designed that alternative reductions can be fitted to make the railcar suitable for various classes of service. The output shaft of the main gear-gox—see Fig. 3—carries a single helical ground gear meshing with a similar gear on the driven shaft, which is offset to one side and below—see Fig. 7—and transmits the drive to the axles. By observation of the drawing, it will be seen that it is a comparatively simple job to remove the covers and slide the gears off the splined shafts, replacing them by others with a different ratio. The following table indicates the ratios available, the resulting top speeds, tractive efforts on bottom gear, and class of work for which they make the railcar suitable. These figures have been estimated by the firm, leaving very liberal allowances for transmission line and other losses :—

| Ratio. | Top speed. m.p.h. | Maximum tractive effort. lb. | Service. |
|---|---|---|---|
| 1·03 : 1 | 75 | 4360 | Express |
| 1·15 : 1 | 67·1 | 4890 | Express |
| 1·37 : 1 | 56·5 | 5810 | Local with trailer |
| 1·73 : 1 | 44·6 | 7370 | More than one trailer ; or heavy gradients |
| 1·96 : 1 | 39·5 | 8340 | More than one trailer ; or heavy gradients |

The drawing, Fig. 3, also shows the arrangement of the drive to one of the exhausters for the vacuum brakes.

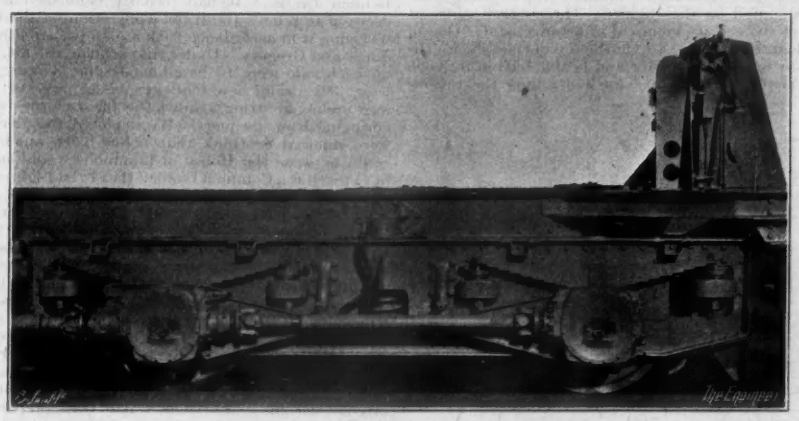


FIG. 5—DRIVING SIDE OF BOGIE

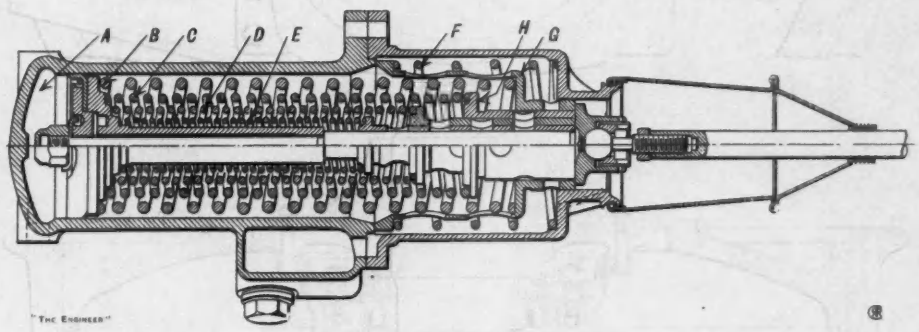



FIG. 6—PNEUMATIC GEAR SELECTOR

It has already been mentioned that a pneumatic system of operating the controls has been adopted. For preselecting the gears in the Wilson gear-box, an ingenious device has been designed and is illustrated in Fig. 6. A handle on the driver's control table operates a self-lapping valve, by the use of which the air pressure in the line can be altered in five steps. The other end of the line at the gear-box is connected to the space A of the operating device illustrated. It will be seen that this device consists of a cylinder having a piston upon which four springs B, C, D, and E are arranged to act in opposition to the air pressure. In addition, there is a return spring F. The drawing shows the device in the "neutral" selected position. On moving the control handle on the driver's table to first gear position, air at a pressure of about 10 lb. per square inch is admitted to space A. This pressure is sufficient to compress the spring F, and consequently the piston travels until the cage G of spring B abuts against the casing. As the pressure is not sufficient to compress both springs F and B, the motion of the piston stops. By this action first gear is selected. On further motion of the control handle the pressure in space A is increased to about 21 lb. per square inch. Spring B is then compressed until the cage H of spring C abuts against the stop, when the piston can travel no further. Thereby second gear is selected. Third, fourth, and top gears are selected in a similar manner, the final air pressure being 80 lb. per square inch.

### Axle-boxes.

From the gear-box the drive is transmitted to the axles through a telescopic propeller shaft mounted between universal joints. The final drive to the axles has been completely redesigned. The arrangement formerly adopted consisted of a worm drive to each axle with an inter-axle differential, and has proved very satisfactory and efficient in service. But as a result of service experience, it is now considered that the inter-axle differential is an unnecessary refinement. Its elimination has not only allowed a very simple bevel drive to be adopted, but has also made it possible to incorporate the reverse gear very neatly in the same arrangement. The design of the drive to the inner axle of the bogie is shown in Fig. 9. Two pinions carried freely in ball and roller bearings are constantly in mesh with a crown wheel bolted to the wheel hub. The driving shaft passes through the bore of the first pinion, and is guided at its end in the bore of the second by a small roller bearing. Sliding dog clutches allow either of the two bevels to be engaged with the driving shaft. Since the bevels are situated at opposite sides of the crown wheel, forward or reverse gear is engaged according as to which bevel is transmitting the drive. The arrangement of the drive to the outer axle of the bogie is similar, except that there is only one bevel pinion situated at the edge of the crown wheel furthest from the engine. It is driven from the corresponding bevel pinion on the inner axle, to which it is connected by a propeller shaft. The arrangement of these two bevels constitutes a definite linkage between the two axles, so that the outer axle must always rotate in the same direction as the inner one.

The pneumatic reversing device is also shown in Fig. 7. The forks which operate the dog clutches are carried by an overhead rod. The latter has at each end a piston working in a pneumatic cylinder, and either clutch can be engaged by admitting air to one or other of the cylinders. It will be seen that no provision is made for engaging a "neutral" position. But in the case of an emergency arising such that it becomes desirable that the whole of the transmission system on one side of the coach should be put out of action, arrangements have been made for holding the clutch rod in the neutral position. It will be seen from the drawing that at the head of each pneumatic cylinder there is a stop in the form of a double-ended set screw. These screws are placed in a position easily accessible from rail level, and if withdrawn and

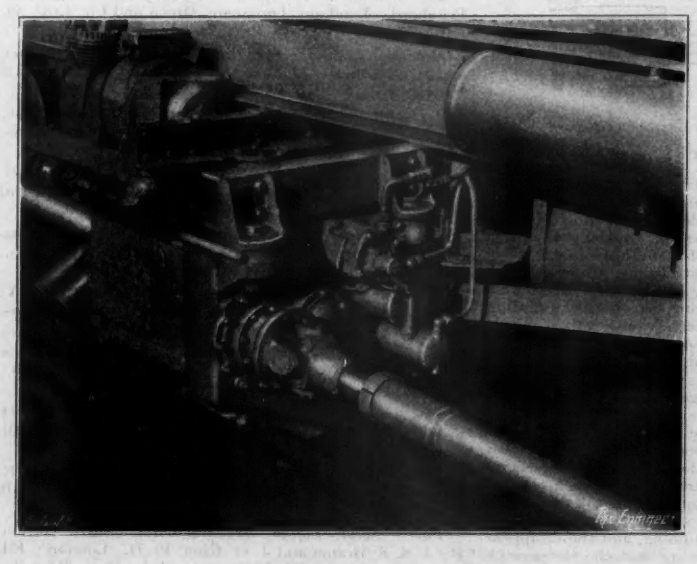


FIG. 7—MOUNTING OF GEAR-BOX

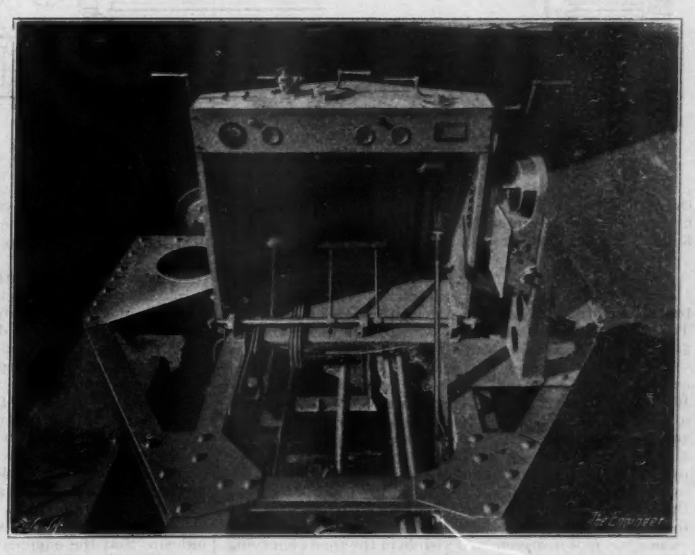


FIG. 8—CONTROL TABLE

replaced with the long end inwards prevent the movement of the clutch rod from the central "neutral" position.

In order that the driver shall be unable to attempt to engage reverse when the train is in motion, an interlock is provided and operated by the vacuum in the brake train pipe. So long as any vacuum exists in this pipe, the reversing handle on the control desk cannot be put in the reverse position. Thus the handle can only be moved when the car is at rest with the brakes fully applied.

The torque reaction from the axle-boxes is taken on to the bogie sole plate by means of pressed arms bolted to the axle-box casing and held at their outer ends by shackles and pins fitted with Silentbloc bushes. Owing to torsional movement, it follows that the axle casing will not remain exactly vertical under all conditions of loading, and in order that the thrust from the axle-box to the horn guides may be square, the thrust faces of the axle-box are carried on a sleeve, which is free to rotate around the main axle casing and remains square with the horn guides. As will be seen from the tone engraving, Fig. 5, the axle-boxes have large inspection covers. They are fitted with oil filler plugs, oil dipsticks, and a magnetic filter. The bevel wheel ratio is 2·588 : 1.

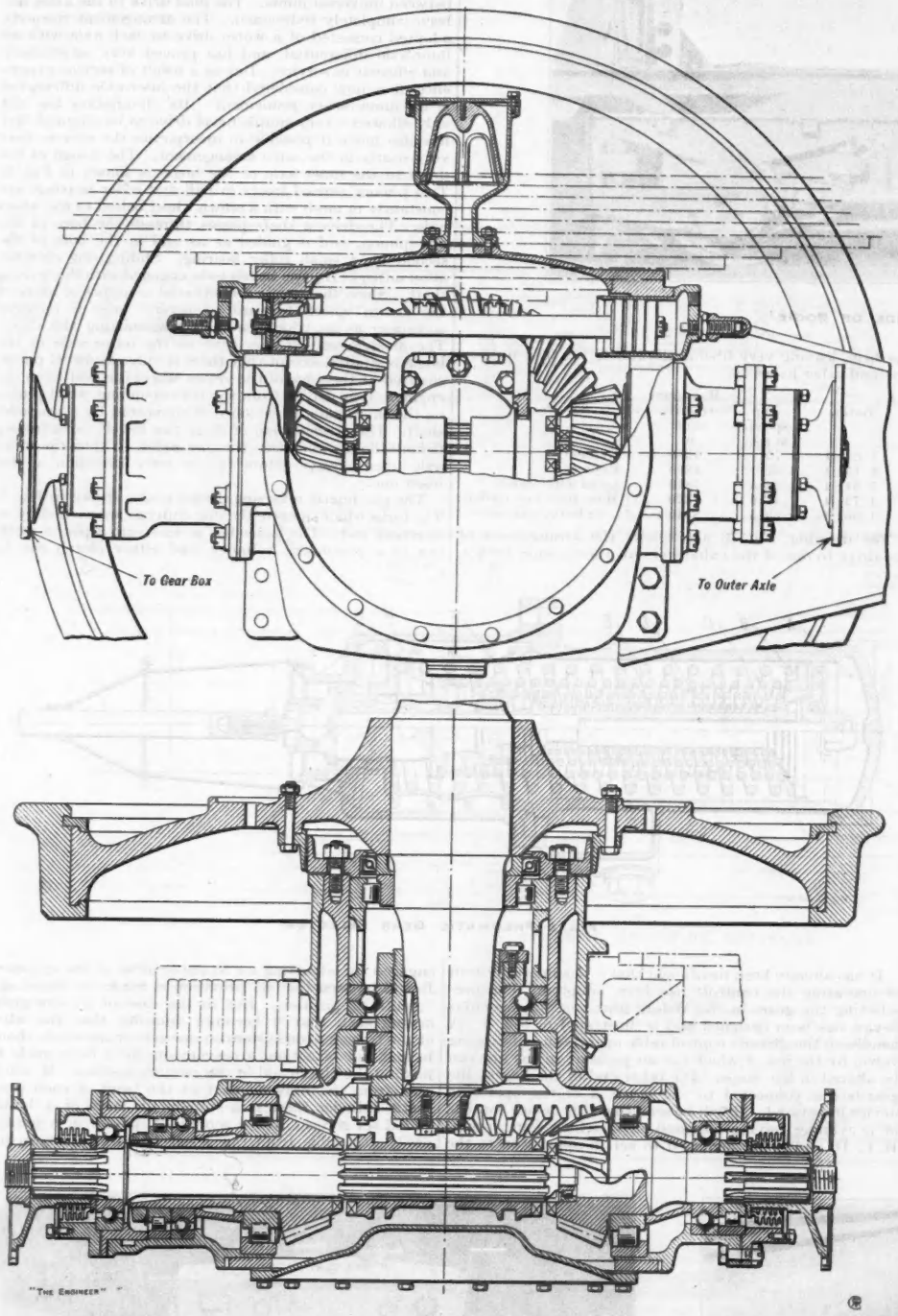



FIG. 9—ARRANGEMENT OF BEVEL DRIVE TO INNER AXLE

### Brakes.

As on previous Hardy railcars, internal expanding brakes are fitted. The general design remains unchanged. The drums are machined from steel stampings, and are 20in. diameter and 6in. wide. The brake shoes are cam-operated, and the cams and pivot pins are mounted on a casting which is carried on the axle by roller bearings. Brake reaction is taken by a torque arm bolted to this casting, and attached to the bogie frame through shackles and Silentbloc bushes. The brakes are operated by an automatic vacuum system, the cylinder for which is mounted on the torque arm, so that there is no relative movement or lost motion. Vacuum for the operation of the brakes is provided by two rotary exhausters, one mounted on the rear of each main gear-box. A third exhauster, motor-driven, and visible in the tone engraving, Fig. 4, is carried on the side of the main frame, and utilised for creating vacuum initially before the engines have been started. Large-capacity vacuum reservoirs are carried between the main frame members.

### Controls.

In this new railcar pneumatic connection of the controls has been adopted rather than mechanical, owing in part to the superior neatness of arrangement that can be thus attained and in part to the ease with which distant operation, from the far end of a trailer, for instance, can be arranged. Only the throttle is mechanically connected, the reason for this exception being that this control must necessarily be used while starting the engine and before any air pressure can be developed. Air for the operation of the controls is obtained from small compressors mounted on the engines. The control tables at each end of the car are identical in arrangement. One of them is illustrated in Fig. 8. On the top of the table to the left are four buttons, a starter and heater button for each engine. Next comes a valve for controlling the reverse gear, followed by a valve operating the preselector mechanism for the gear-box. The handle to the right on top of the table is the brake. Two pedals operate the gear change and throttle respectively. In addition to the foot throttle, there is on each side of the control table a hand throttle so placed as to be within easy reach of the driver when leaning out of the window during fog or when shunting. The face of the control desk carries push valves for the whistle and engine stop, a speedometer, vacuum gauge, reservoir air pressure gauge, and gear selector gauge. The last-named indicates at night what during the day is shown by the position of the gear selector handle. The remaining handle, that on the right side of the table, operates the sanding gear. The hand brake visible in the engraving acts only upon the bogie at one end of the car, and is chiefly of use for holding the vehicle when the engines are at rest. Indicator lights are arranged on a panel so placed that though it can be easily seen, it will not confuse the driver when looking at the signals. Two green lights indicate that the engines are running, and the disappearance of a blue light gives warning that the temperature of the water or oil in one or both of the engines is too high. The remaining lights, a red and a white, indicate at which end of the car the tail lamp has been switched on.

Underneath the buffer beam a control coupling is fitted to which all control pipes are connected. It is arranged to connect up with a similar coupling on a trailer or a second car.

## SIXTY YEARS AGO.

In our issue of November 5th 1875 we expressed in strong terms our disapproval of the action which the Corporation of London proposed to take concerning London Bridge. It had recently confirmed a previous decision to relieve the traffic congestion on the bridge by widening it in accordance with a plan prepared by Messrs. Jones and Gregory. Under that scheme the 8ft. footways on each side were to be added to the existing carriageway, 38ft. wide, new footways being provided on light iron arches abutting against the faces of the bridge and springing from its piers. We deplored this decision but were rejoiced to think that before very much mischief could be done the House of Commons would surely step in to teach the Common Council that it had less real power over London Bridge than it imagined. We admitted that the congestion was acute. Four lanes of traffic were carried by the bridge. At each end the police marshalled the vehicles into a fast and a slow moving stream and in this process of marshalling there was in itself a cause of congestion. Further the space available on the bridge for each lane was only 9½ft. wide so that if a horse fell or a vehicle came to grief while crossing there was no opportunity of the obstruction being by-passed. The truth was, we said, that London Bridge from the very start had been too narrow. Initially, we recalled, it had been intended to build it with an overall width of only 48ft. but after the original designs and estimates had been prepared it was decided to increase the width to 54ft. at an extra cost of £46,000. We objected to the Corporation's proposal partly on æsthetic grounds for we could conceive of nothing more paltry or hideous than the pasting of incongruous and meagre circular iron arches on to the noble granite structure with its elliptic arches which the Rennies had given us. Our objections also were based on strictly utilitarian considerations. We pointed out that the proposed scheme would add at the most 16ft. and possibly only 13ft. to the width of the carriageway and that with such additional width six lanes of traffic would be accommodated only if each could be confined to 9ft. of the roadway. If only one additional lane was to be accommodated the scheme would be futile since as much traffic poured across the bridge in one direction as in the other. During his lifetime, we stated, Sir John Rennie had had to oppose several projects, far better than the one favoured by the Corporation, for widening the bridge. If such widening were ever undertaken we urged that it should be on a scale adequate for all futurity. Nothing less than doubling the existing width would be adequate. Our solution of the problem lay in the construction of a new bridge lower down the river. . . . In due course London Bridge was widened by corbelling out the footways from each face and also in due course a new bridge, Tower Bridge, was built substantially on the site we had suggested.

## BOOKS RECEIVED.

*Industrial Electronics.* By F. H. Gulliksen and E. H. Veeder. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 17s. 6d. net.

*Wireless Telegraphy: Notes for Students.* By W. E. Crook. London: Sir Isaac Pitman and Sons, Ltd., Parket-street, W.C.2. Price 7s. 6d. net.

*Praktische Anwendung der Baugrundutsurchungen.* By Dr.-Ing. W. Loos. Berlin: Julius Springer, Linkstrass 23–24, W.9, Germany. Price 11 marks.

*The Lay-out of Small Water Mains.* By H. H. Hellins, M. Inst. C.E. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 7s. 6d. net.

*Elements of Electrical Engineering.* Third edition. By A. L. Cook. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 20s. net.

*Britain in Depression: A Record of British Industries since* 1929. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 10s. 6d. net.

*The Book of the Aeroplane.* By Captain J. Laurence Pritchard. London: Longmans, Green and Co., Ltd., 39, Paternoster-row, E.C.4. Price 7s. 6d. net.

*Materials Testing.* Second edition. By I. H. Cowdrey and R. G. Adams. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 8s. 6d. net.

*A Comprehensive Treatise on Practical Mechanics.* By J. M. Lacy, M. Inst. C.E. London: Technical Press, Ltd., Ave Maria-lane, E.C.4. Price 18s. net.

*Review of Oxidation and Scaling of Heated Solid Metals.* London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C.2. Price 2s. 6d. net.

*Elements of Strength of Materials.* By S. Timoshenko and G. H. MacCulloch. London: MacMillan and Co., Ltd., St. Martin's-street, W.C.2. Price 14s. net.

*Strength of Materials.* Second edition. By F. V. Warnock, Ph.D. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 10s. 6d. net.

*Elementary Electrical Engineering.* By A. E. Clayton and H. J. Shelley. London: Longmans, Green and Co., Ltd., 39, Paternoster-row, E.C.4. Price 7s. 6d. net.

*Elements of Machine Design.* Third edition. By D. S. Kimball and J. H. Barr. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 20s. net.

*Strength of Materials.* Second edition. By E. R. Maurer and M. O. Withey. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C.2. Price 17s. 6d. net.

*Fuel: Solid, Liquid, and Gaseous.* Fourth edition. By J. S. S. Brame and J. G. King, Ph.D. London: Ed. Arnold and Co., 41, Maddox-street, W.1. Price 25s. net.

## Rail and Road.

THE death occurred on October 30th of Mr. Herbert Marriott, who was for four years on the L. and Y., and served later on the L.M.S., was the British representative on the panel appointed under the League of Nations to deal with international disputes on railway matters arising out of the treaty of peace, and acted in that capacity in connection with traffic movements in the Saar territory.

THE Great Western Railway announces that during the next twelve months 406 miles of its line are to be completely relayed or partially renewed. The work will involve the use of the following materials :—30,200 tons of new rails, 16,500 tons of cast iron chairs, 5160 tons of bolts and fish-plates, 5100 loads of crossing timbers, 623,000 sleepers, 198,000 cubic yards of ballast, 2,750,000 "keys."

ACCORDING to the Board of Trade export tables the value of the railway material shipped overseas during the first nine months of the present year was as follows, the corresponding figures for 1934 being added in parentheses :— Locomotives, £527,404 (£209,027) ; carriages and wagons, £875,883 (£638,767) ; rails, £656,629 (£817,250) ; wheels, metal sleepers, fish-plates, and miscellaneous materials, £1,420,784 (£875,065).

THE fourth annual report of the Traffic Area Commissioners, under the Road Traffic Acts, has now been issued, price 2s. 6d. It shows that at the end of 1934 the number of persons carrying on the business of operating public service vehicles was 5723, and the number of vehicles they operated 45,746, a reduction of 584 in the number of operators and of 712 vehicles compared with 1932. In the Northern Traffic area there were 445 women who were licensed as conductors.

THE Ministry of Transport railway statistics for July show that, compared with the corresponding month of 1934, there was an increase of 6·1 per cent. in the number of passenger journeys, and of 6·6 per cent. in the receipts from passengers. The tonnage of freight carried decreased by 1·0 per cent., and the freight receipts by 1·3 per cent. Freight train mileage rose by 0·3 per cent., but the average train load fell from 117½ to 116¾ tons, and the net ton-miles per engine-hour from 442½ to 440.

SHELTERS are being provided at various places in London and the Home Counties for the convenience of passengers by the Green Line coaches of the London Passenger Transport Board. These are in the familiar green and black of the Board's coach service. Similar shelters are to be erected at all important traffic points along the coach and country omnibus routes, and will contain time-tables and maps. "Stop" signs have been erected throughout the Metropolitan Police District, in which coaches may only pick up passengers at prescribed places, and at points outside the district.

IN response to the inquiry made by "Still Wondering" in his letter on "Railway Accidents" on page 459 of our issue of November 1st, we would say that we do not know if any modification of the flange of the wheels of locomotives has affected the number of derailments. We are, however, able to give some figures that suggest that such is the case. Between May, 1908, and June, 1912, inclusive, there were four derailments reported upon by the Board of Trade inspecting officers, which were caused, it was alleged, by the flange of the wheel being worn. During the period of twenty-three years that has elapsed since the case in June, 1912, there has been no report issued on an accident from that cause. There was, however, a derailment on January 13th, 1928, on the Severn Valley branch of the Great Western, in which decayed sleepers and a heavy tank engine punishing the road figured. Colonel Mount inquired into the accident, and in the concluding paragraph of his report drew general attention to the fact that the Great Western had adopted, since the previous August, "the eminently desirable policy of deepening all engine flanges by ¼in." We thereupon communicated with Mr. Collett the chief mechanical engineer, who, in reply, reminded us that the contour of locomotive tires was the subject of British Engineering Standards Association Specification No. 276, of 1927. Some derailments of engines that had the standard section suggested to Mr. Collett that the flange should be deeper, and he took that step with satisfactory results. He, moreover, advised his colleagues on the other main lines what he had done. The whole of the facts will be found in THE ENGINEER for Aug. 10th, 1928.

IT was on November 11th, 1890, that a railway accident occurred which gave considerable concern to railway signal engineers. A goods train was crossed from the down to the up line at Norton Fitzwarren on the Great Western Railway for another train to pass it. The standing train was afterwards forgotten and the signalman accepted and lowered his signals for an up special express from Plymouth, with passengers and mails from the Cape. Ten passengers were killed. The driver of the goods train failed to change the head light on his engine from white to red, and the guard omitted to go to the signal-box to remind the man there of the presence of the train ; both these duties were laid down in the rule book. It was characteristic of Colonel Rich, who inquired into the disaster, that his report was contained in 3¾ pages, and his conclusions and recommendations in three-quarters of a page. As a consequence of this accident, signal engineers devised various means of interlocking which necessitated, after a train had been crossed, as in this case, from the down to the up line, that the train to return to the down line, or to be placed in an up siding, or to go away on the up line would have to do so before the up home signal could be lowered for an up train to approach. Mr. Thomas Wharmby, the Great Central signal superintendent, devised such an arrangement for which his chief, Mr. Alexander Ross, took out the patent specification. Mr. W. G. Scott, the Cheshire Lines Committee's chief engineer, also took out a patent for something similar, and the two parties combined their ideas in the Scott-Ross locking. The accident led to the next issue, in 1892, of the Board of Trade requirements for new railways, securing "that some simple means should be supplied for reminding" signalmen of shunted trains. Track circuit now safeguards all standing trains from being overlooked.

## Miscellanea.

A DIRECT radio-telephone service is to be opened between France and the United States before next July.

MR. WM. REAVELL has been re-elected President of the British Engineers' Association for the coming year.

THE value of machinery and equipment orders placed in this country by the Soviet during the period January to September increased from £1,205,062 in 1934 to £1,775,853 this year.

A NATIONAL Coal Convention, the first of its kind to be held in this country, will meet in London on November 21st and 22nd. It is promoted by the Coal Utilisation Council and supported by the Mining Association, the Coal Merchants' Federation, the National Council of Coal Traders, and the British Exporters' Federation.

THE B.B.C. announces the purchase of a site near Newcastle for the North-East Regional Station. A number of sites have been tested, but the choice was restricted to some extent by the necessity of avoiding the area surrounding Hadrian's Wall, which is preserved as an ancient monument. The site chosen is at Bewclay, near Corbridge, about 16 miles west of Newcastle. Preliminary work in connection with the construction of the station is in hand.

ACCORDING to a note in the *Iron and Coal Trades Review*, Ruhr coal producers have combined to form the Ruhr Petrol Company, which is to produce petrol from coal by the Fischer Tropsch process. About 80 per cent. of the Ruhr coal producers are participating in the new concern. The capacity of the new company is estimated at 25,000 tons of petrol a year. Construction of the necessary plant has already begun and is expected to be completed by the end of 1936.

DISCUSSING storage batteries, Mr. E. C. McKinnon, in a recent paper, said that during the past thirty-five years the average life of the submarine battery has been increased by nearly 300 per cent. The watt-hour capacity has been trebled, and a single cell may have an output of 15,000 ampère-hours and weigh 1½ tons. In contrast, a military aeroplane battery rated at 430 watt-hours for ten hours at 11¼ volts weighs only 46 lb. It would give over 1100 watts for five minutes and would yield over 9½ watt-hours per pound at the ten-hour rate.

SOME fruit growers in California, U.S.A., have adopted a new method of combating frost in their orange groves. The equipment used consists of a 450 h.p. aeroplane engine driving an 8ft. propeller, the engine and propeller being mounted on a 40ft. high steel tower, the platform of which slowly revolves when the engine is running. It is a known fact that frost needs cold still air to settle, and the spinning blade creates a wind which circulates the cold air before it can settle close to the ground. It has been found that one engine working can keep a 40 to 50-acre area clear of frost.

SALFORD police are experimenting with a new type of fog flare at cross roads. The device comprises a box permanently installed at cross roads ; in this box are stored a series of tubes and a tap connected to a gas main. In the case of fog the box is opened and the tubes joined together and fitted on to the gas tap ; the tap is turned on and a light applied to the topmost tube, igniting a flare which is visible for several yards. It is stated that the success of the flare depends on whether in dense fog a suitable burner can be found, and experiments are being carried out in this direction.

RAPID progress is being made on the cantilever bridge in the East Bay crossing of the San Francisco-Oakland Bridge in the United States. Having a main span of 1400ft., when completed, this will be the longest cantilever bridge in the country, whilst its deck, accommodating six lanes of vehicles on an upper level and three lanes of vehicles and two rapid transit tracks on a lower level, will give it a greater weight capacity than any cantilever in the United States and a greater transportation capacity than the only two cantilever bridges that exceed it in size—the Quebec Bridge in Canada and the Forth Bridge in Scotland.

THE National Employers' Mutual General Insurance Company, Ltd., has in the past published booklets showing the causes of accidents and suggesting preventative measures in the iron and steel industry and the building and allied trades. As a result of the frequency and severity of circular saw injuries, not only in timber yards, furniture, and other wood-working factories, but in service departments concerned with the production of packing cases, pattern shops attached to foundries, and maintenance sections, it has now produced a new booklet, entitled "Reducing Danger from Circular Saws," for the guidance of those concerned.

THE Postmaster-General recently announced that since the telephone rates were reduced in October, 1934, some 200,000 additional telephones had been installed, and that in January next a number of new concessions would come into effect. Amongst other developments, the circuits between London and Edinburgh have been increased from seven to twenty-seven and between London and Plymouth from five to seventeen. Altogether more than 600 additional circuits have been brought into use on some 200 routes. In twelve months the G.P.O. has more than doubled the capacity of the trunk network on the larger routes and now has a larger proportion of underground lines than any other large telephone system.

SPEAKING at a recent conference, Dr. R. Veitch Clark suggested that "Joint Smoke Boards" should be set up to control the emission of smoke throughout the country, each Board covering an area of sufficient size to make an effective standardisation of smoke emission generally practicable. Dr. Clark referred to the difficulty of securing effective smoke abatement by small local authorities, and said Smoke Boards would be far in advance of any penal legal enactments. The scheme would help to obviate the real financial waste of British fuel resources and the serious and extensive damage done to agriculture. The stock-carrying capacity of pasture land affected by smoke had been shown to be diminished by one-sixth of its original value.

## Air and Water.

AN air mail service has been inaugurated between Bombay and Trivandrum.

THE Air Ministry has licensed the new aerodrome at Alderney in the Channel Islands.

THE name of the flagship of the Hamburg-Amerika Line is to be changed from "Albert Ballin" to "Hansa."

THE French steamship service to Australia, operated by the Messageries Maritimes, has been stopped by order of the French Government.

IT is announced by the United States Department of Commerce that it will construct a 30,000-ton liner of the "Manhattan" or "Washington" class.

THE Air Ministry has placed an order for seventy-five Vickers general purpose monoplanes. The machines will be fitted with Bristol "Pegasus" 850 h.p. engines.

THE formal investigation into the circumstances attending the loss of the tank steamship "La Crescenta" has been fixed for hearing at the Institution of Civil Engineers on Monday, November 18th.

IMMEDIATELY after the launch of the Blue Star Line's refrigerated motor ship "Dunedin Star" at Birkenhead, workmen began to lay the keel of the vessel's 12,000-ton sister ship on the same stocks.

THE Imperial Airways liner "Atalanta" was wrecked when taking off at the Kisumu Aerodrome at Nairobi on Sunday morning, November 3rd. The pilot and first officer were slightly hurt, and the passengers only shaken.

ARRANGEMENTS have been completed between Pan American Airways and the New Zealand Government, by which it is probable that an air service between the two countries will be started with flying boats next August.

THE Cunard-White Star Line has issued a statement to the effect that the report that the "Berengaria" is to be withdrawn from service or broken up when the "Queen Mary" is commissioned is unauthorised and that no consideration has yet been given to the matter.

THE first sailing of the "Queen Mary" has been scheduled to take place from Southampton and Cherbourg on Wednesday, May 27th next. On the return voyage the vessel is scheduled to sail from New York on Friday, June 5th, for Cherbourg and Southampton.

THE liquidator of the affairs of Messrs. D. and W. Henderson and Co. has concluded an agreement for the sale of the complete shipyard to National Shipbuilders' Security, Ltd., which, it is understood, proposes to keep the yard intact on a care and maintenance basis in the hope of better trade, and to continue the dockyard and repairing business.

THE combined air liner postal service worked by the N.D.L. and the Luft Hansa has completed six years of successful operation. The saving in time on the delivery of letters has been seventeen to twenty-four hours to America, and as much as forty-eight hours to Europe. The record flight was made from the "Bremen" when 900 miles from New York, the mails being delivered in less than four days.

THE Tyneside Industrial Development Board is reviving a £1,000,000 scheme for the construction of deep water quays on a large area of land known as the Slake at Jarrow-on-Tyne. The secretary to the Board stated that in March this year the Special Areas Commissioner offered a grant of £250,000 to the Tyne Improvement Commission towards a scheme for erecting quays at Jarrow, subject to an arrangement being entered into with the London and North-Eastern Railway. These negotiations, however, had fallen through.

IN a recent paper before the Institute of Actuaries Mr. C. Richardson, giving figures covering both internal and external flying by British aviation companies, said that 12 out of 28,327 passengers were killed in 1929, while in 1934 only 9 out of the 135,000 persons carried were killed, the passenger mileage in these two years being 7,147,000 and 29,091,000 respectively. In the six years the mortality rate for every 1000 passenger flights was only 0·130. Mr. Richardson, however, emphasised the shortage of data and its lack of homogeneity.

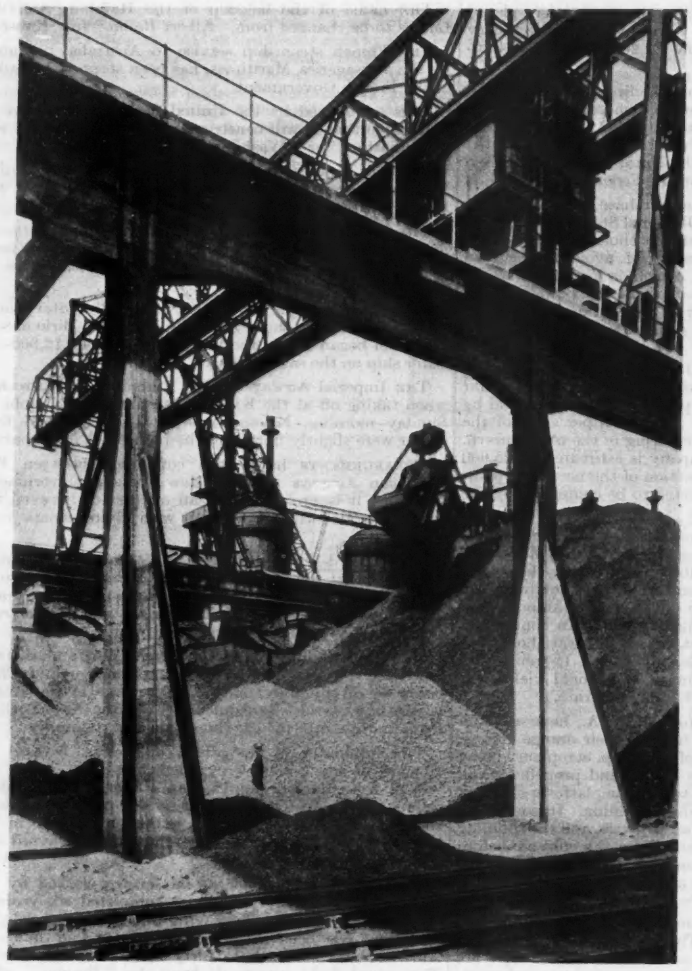
IN a recent interview, the President of the National Council of American Shipbuilders, Mr. G. Smith, pointed out that fully 90 per cent. of the United States' sea-going merchant fleet was rapidly approaching obsolescence ; that the construction of new merchant tonnage to take the place of these obsolete vessels was practically nil, and that constructive legislation to clarify the present situation was imperative. He also stated that since 1925 Great Britain had constructed 617 sea-going freighters, each of 2000 gross tons or over, while during the same period the United States had built only seven such vessels, of which only two were engaged in general trade. The other five included three vessels designed for the carriage of freight cars, and two colliers.

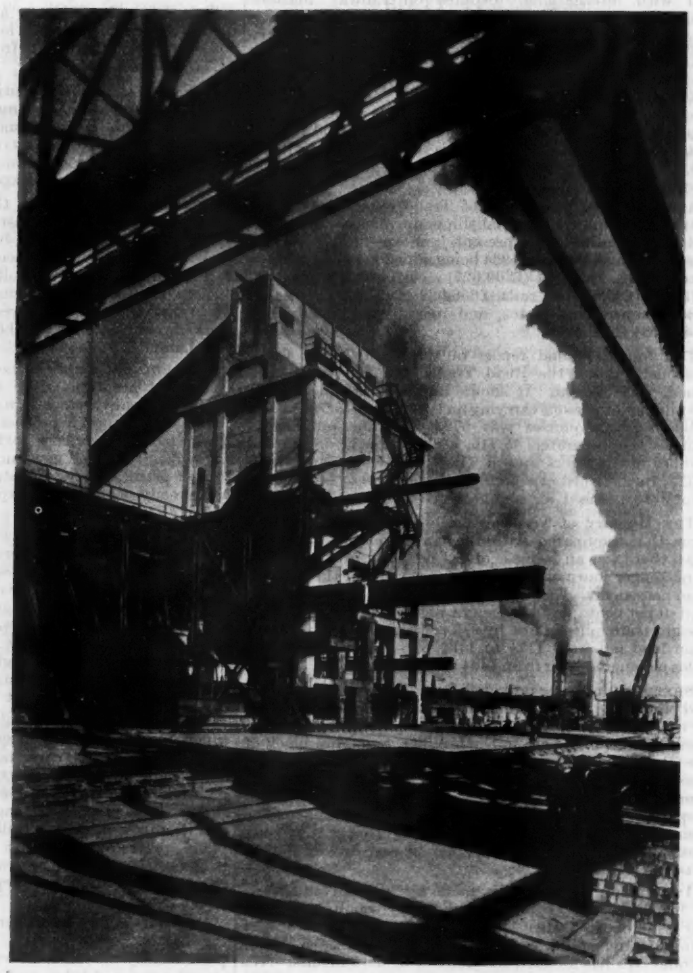
THE de Havilland four-engined express air liner, D.H.86, introduced in January, 1934, is to be produced in two new and improved models. One will continue to be fitted with standard "Gipsy Six" engines driving ordinary fixed-pitch air screws, but in the second model a new series of higher powered "Gipsy Six" engines will be installed and fitted with de Havilland controllable pitch air screws. This new series of engines is rated to give a higher continuous power output than the standard type, and has a compression ratio of 6 : 1, as compared with the standard compression ratio of 5·25 : 1. The use of fuel of a higher octane rating will be necessary. The design will embody the hydraulic mechanism by which the air screw blades are controlled. In order to remove the drag effect set up by external venturis, a vacuum pump will be incorporated to drive the gyroscopes of the navigation instruments. Furthermore, anticipating the coming availability of automatic pilot mechanism, the new series of engines can, if required, be fitted with an oil servo pump to provide the necessary driving power which will be needed, while provision has been made in the aircraft for the installation of the P.B. automatic pilot.

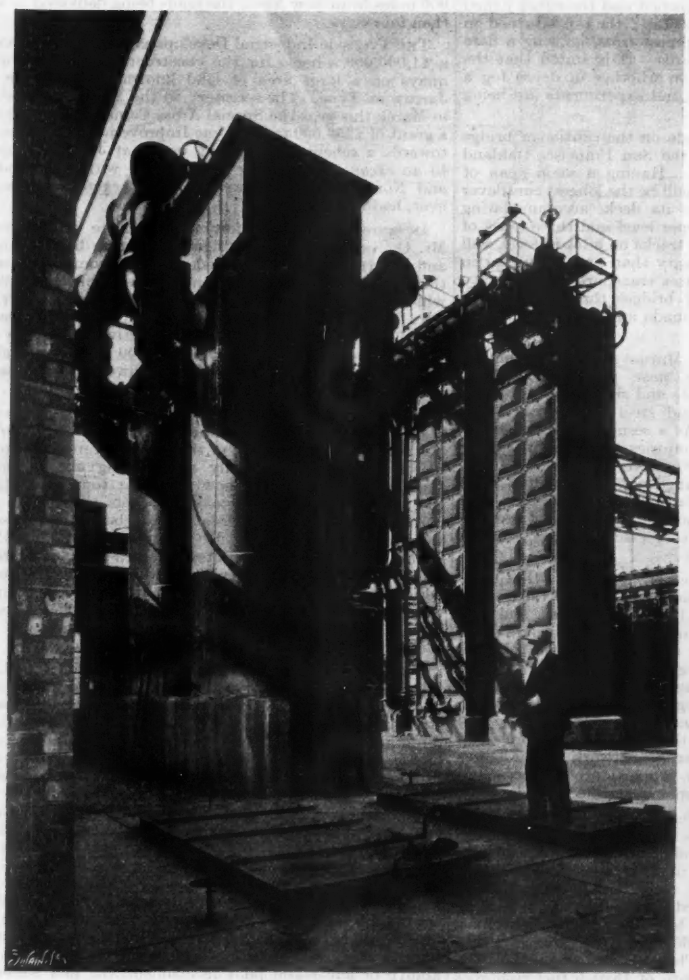
# CORBY IRON AND STEEL WORKS

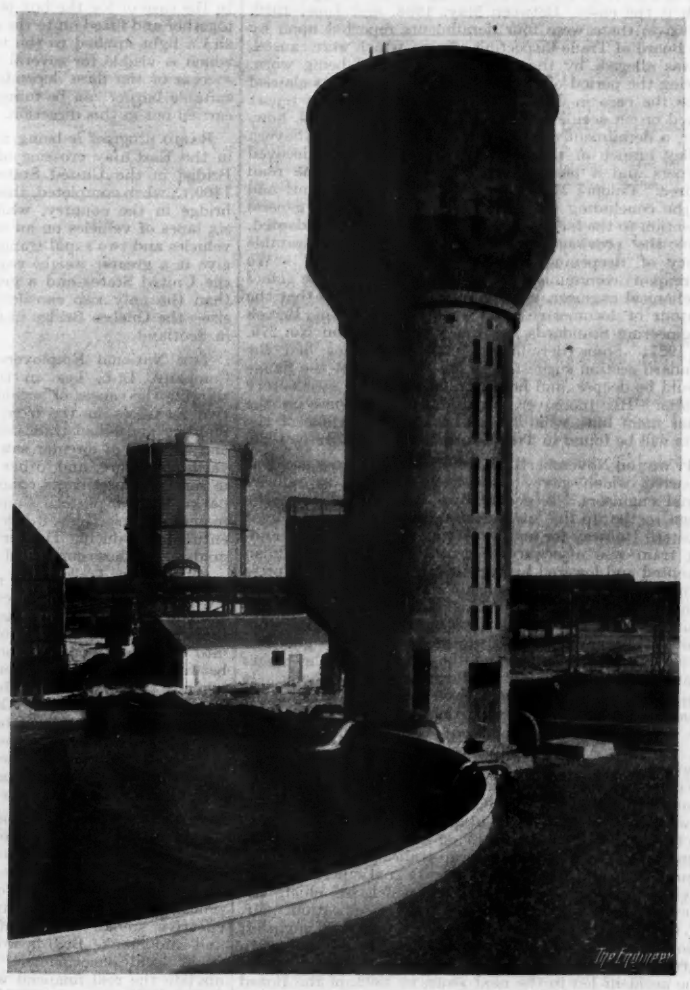
H. A. BRASSERT AND CO., LTD., LONDON, DESIGNERS AND ENGINEERS

(*For description see page 474.*)









ABOVE:—ORE-HANDLING BRIDGE, STOVES, AND BLAST FURNACES
BELOW:—BY-PRODUCT PLANT COOLING AND CONDENSING TOWERS

ABOVE:—BECKER COKE PLANT, COAL BIN, AND QUENCHING STATION
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*NOVEMBER* 8, 1935.

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**** All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

**** No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGES OF ADDRESS.

**** Will subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses**, *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

## THE FAILURE OF METALS UNDER STRESS.

THERE can be but little doubt that the paper presented by Dr. Gough and Mr. Pollard before the Institution of Mechanical Engineers at Manchester on October 17th and in London on Friday of last week marks the opening of a new chapter in our knowledge of the behaviour of metals under stress. Not a few will perhaps be surprised to learn that, after so many years of intensive and widespread research on the subject, there can be any aspect of it of material practical importance left to explore. It is certainly true that a vast amount of information has been accumulated concerning the behaviour of metals under static stress of one form or another, concerning their behaviour under a combination of two static stresses, and concerning their behaviour under alternating or repeated stress of one kind at a time. A limited amount of information is available regarding the behaviour of metals when subjected to an alternating stress in combination with a static stress. With, however, the single exception of a British Association paper of 1916 by Stanton and Batson, nothing previously has been published regarding the behaviour of metals under two alternating stresses of different kinds acting simultaneously. It is this field which Dr. Gough has set out to explore. So far he has begun to investigate only one small corner of it. He has selected plane bending and torsional cyclic stresses as the particular combination to be studied and has restricted his outlook to the case in which the two stresses rise and fall in phase through ranges equally disposed about the zero stress value. Even within this confined field, as Dr. Gough himself has said, the work waiting to be done is more than the National Physical Laboratory can hope to complete in a reasonable time. Additional information on the subject may, however, shortly be expected from America where it has recently been studied. The University of Göttingen, too, will doubtlessly soon be in a position to add fresh data for it is now equipped with a machine by which combined cyclical stress tests may be conducted. Further, certain firms are likely in their own interests to acquire, as they are at liberty to do, copies of Dr. Gough's machine, and carry out their own researches on those aspects of the subject which are of particular moment to them, following in this respect the example of the Bristol Aeroplane Company which already possesses two of the machines. The general results so far obtained by Dr. Gough relate to a mild steel, an alloy steel and a special cast iron and will be found set forth in a special summary of the paper which we publish elsewhere in this issue.

If it did nothing else the paper would still be valuable by virtue of the fact that it directs prominent attention to our ignorance concerning the fundamental reason or reasons why metals fail under load. When we say that a specimen under tension fails because the applied load exceeds the ultimate tensile strength of the metal we do little more than cover our ignorance with a form of words. The statement evades the real issue and is entirely non-committal as to the factors which determine the ultimate strength or even as to why there should be any ultimate strength at all. A more decisive, but not necessarily a more correct, statement would be that the metal failed because the strain induced in it separated its molecules to distances at which the sum of the intermolecular forces across the surface of failure became less than the applied load. This explanation may or may not be well founded but, one way or the other, it is at present too fundamental to be of practical value. An explanation of a kind intermediate between a platitude like the first and a fundamental assertion like the second might be given. We might say, for example, that the failure of the metal arose because the elastic strain energy per unit volume, imparted progressively during the earlier stages of the test, reached, at the point of failure, a limiting value characteristic of the metal. Other criteria of a similar intermediate nature might be given. At present there is no certain knowledge as to which is the most reasonable and most likely to be true. This condition of uncertainty increases rapidly as we pass from the simple circumstances of a straight tensile test to tests involving a more complex application of stress. We may have a combined loading consisting of two static stresses. In this case there are at least six different theories available to explain why the metal fails. The simplest, Guest's theory, states in effect that the metal fails because the resultant shear induced by the combined loading exceeds the ultimate shearing strength of the metal. Such a statement differs from a platitude only in so far that it particularises the shearing load and strength and neglects the co-existing resultant tensile or compressive load and strength as the criterion determining failure. Of the other theories and their sundry modifications we need here mention only one, that associated with the names of von Mises and Hencky. This theory, like Guest's, fastens, apparently in an arbitrary manner, upon the shear factor as the decisive influence. It states that failure occurs when the energy stored in the metal as a result of the shear strain, neglecting the tensile and compressive strain energy, reaches a limiting value. This particular theory, it may be added, has recently received a fair amount of experimental support and is in consequence a popular one at the moment. When we pass from simple or combined static loading to the conditions of a fatigue test with a single form of stress, we enter a field in which the explanation of failure is a subject of the greatest speculation. Bauschinger in 1886 advanced a theory, if theory it can be called, which associated the fatigue strength of a metal with its so-called natural elastic limits. This theory, a working rule rather than an explanation of failure by fatigue, continues to receive consideration. Other views have been advanced, such as one which relates the failure to the occurrence of slip within the crystal grains, but none of them carries us very far towards an even moderately complete and satisfying explanation of failure by fatigue. Finally passing to the conditions of Dr. Gough's research, involving the application simultaneously of two cyclical stresses to a specimen, we find no explanation whatsoever to account for failure of the metal. The best that can be done at present is, as Dr. Gough does, to adopt such theories as are available in explanation of failure under combined static loading and to hope, seemingly against all reason, that they will provide some guidance which will elucidate the cause of failure under combined cyclical stresses. The result of this procedure, so far as Dr. Gough's work has gone at present, is much as might be expected. Each of the three materials tested appears to fail in accordance with a different theory.

We may, perhaps, be taken to task for stressing what appears to be an aspect of the subject which is of abstract scientific interest rather than of practical importance. To any such criticism the reply may be made that the time is not yet ripe to discuss the application of the results to practice. That time will come but for the moment it is very desirable that additional information should be accumulated before practice is modified in light of the investigation. For another and broader reason it seems to us important to dwell, as we have done, on the demonstration which the investigation affords of our ignorance concerning the failure of metals under load. It seems incredible that the true fundamental causes which determine the failure of metals can differ with the manner in which the loading is applied. The fundamental cause may be a function of displacement, velocity, force or energy but whichever it is, it must surely be the same in its nature in failure under single or combined cyclical loading as it is under single or combined static loading. The final effect is the same—the separation of the specimen into two parts, even although the test may not in all cases be carried to such a limit—and, therefore, it is very difficult to believe that a multiplicity of causes can be in action. It follows, then, that any progress towards the discovery of the true cause of failure in metals under one form of loading will assist us to understand their failure under another form. With such understanding the task of the investigator would be enormously simplified and the practical application of his discoveries and results would become obvious and easy.

### Words and Knowledge.

ON another page we print the address which Major Freeth delivered at the annual luncheon of the British Cast Iron Research Association. Type and ink rob it of some of its vitality, but it still remains sufficiently provocative to excite discussion. There are those who will agree with the author and those who will disagree with him. One is as valuable as the other, for in discussions opposition is often as great a propulsive force as approval. Like the reaction in a Laval turbine, it plays its part in keeping the wheel revolving. Major Freeth is not only a scientist with strong views, but in speech his spontaneous manner of delivery gives them a sparkle which enforces attention and arouses either dissension or endorsement. While so many speakers leave one neither hot nor cold, it is pleasant indeed to hear one who does stimulate thought, even if it be "contrariwise."

Take, for example, Major Freeth's acceptance of Liebig's dictum that the "English are not a scientific people." Liebig died sixty-two years ago. Has not the attitude of the English towards science altered in that time? Major Freeth does not think it has, and perhaps he is right. It is, at least, true that we, as a people, dislike and distrust the doctrinaire as much as we ever did. At the social dinner table there is more rejoicing over an error of science than over its triumphs. When one is revealed society feels that it has got one back on someone who has had the arrogance to put it right. The community as a whole can never have, must never be expected to have, the attitude of the scientist towards science. The true scientist does not feel any humiliation in the upsetting of an hypothesis which appeared to be established. He knows that science is marching along a difficult road and that the best that it can do is to say how far it has got at any particular day; if it gets further to-morrow he rejoices and is not in the least ashamed of the fact that he was no further yesterday. In a thoroughly scientific nation every one would look upon the march of science in that light. Possibly, in Liebig's days, Germany and France had reached nearer to that ideal than England; possibly they are still nearer to it than we are. It is, we fear, beyond question, despite the large numbers of young men and young women who are now being taught in one way or another to think scientifically, that science, save by name, is barely known to the general public. Consider the vast ignorance that is passed on to it by many of the daily papers and accepted by it. We have met people who thought that the electrically propelled ship must be more roomy and cheaper than the steamship

because it required no engines! Major Freeth hinted that scientists themselves were responsible for this lack of sympathy with their work because they spoke in a jargon that only they themselves could understand. That is a charge as ancient as science itself. Great men like Tyndall and Faraday and Rosenhain have arisen from time to time, and have made palatable to the general the caviare of science. Some such men are still with us. They lecture at the Royal Institution, but the leaven given to a few spreads slowly, and in distortion, to the many. In his address, Major Freeth was thinking specifically of the metallurgy of cast iron. He expressed the opinion that it, at least, might be made clearer to the uninitiated. We fear he is over sanguine. A new vocabulary has grown up around metallurgy, and it is extremely doubtful that the discoveries, facts, and laws of that new science can be expressed in the few thousands of words in common use. Science is continually producing new ideas, but every new idea calls for the creation of a word to express it. Not until the word is created is complete clarity of thought attainable. For a while scientists struggle to express themselves in phrases each trying by the use of his existing vocabulary to say what he has in mind; but because the vocabulary is unsuitable for the purpose, he fails to make his meaning clear to others. Then some genius clears the matter up, finds a new name for the idea, and the differences of meaning disappear. In science, unlike literature, one word must mean one thing and one thing only. Since nearly all words in common use have several meanings, precision can only be obtained by devising a wholly new word. In metallurgy, there are bushels of specialised words and phrases, and it is to be feared that many of the discoveries in that science cannot be explained at all without the use of them. It may be admitted, however, that the practical issues—the results of the science, but not the science itself—can be put into simple language, and Major Freeth is probably right in thinking that employers and managers would take more interest in scientific research if the facts achieved were put before them in the language of every-day. They distrust science because they do not understand it and mislike the scientist because by his use of words strange to them he seems to give himself airs. No wise man speaks to his guests of the plants in his garden by their Latin names.

Major Freeth is a scientist engaged in a very big business with many ramifications. He speaks out of his own knowledge in his reference to the difficulty of interesting non-technical people in science. He believes, and he should know, that if these people could be approached not in the tongue of the scientist, but in a language that they understand, they would show more spiritual and, we may hope, more material interest in research. The difficulty that we foresee would be to discover men with that rare aptitude for making scientific facts both simple and attractive; particularly when the subject in itself is never romantic and has little or no human attraction. The zoologist may talk of animals, the doctor of bodily health, and the psychologist of human complexes and repressions with a fair certainty of finding a willing audience. But the metallurgist, when he leaves his brother scientists, finds himself faced with men who are interested only in results and the money that can be made from them. Hence the shortest road to their sympathy is to prove to them that science, whether they care to understand it or not, is providing them with new materials out of which industry may make financial profit. Major Freeth may say that that is the very plan which has been followed so far, and that it has not been as successful as could be wished. He offers the alternative of making general employers scientifically minded. If that can be done, well and good; the result would be beneficial to the country as a whole. But we fear that it is well nigh impossible. The annual reports of the work achieved by the British Cast Iron Research Association are, we suspect, as likely to cause active sympathy and participation in research as the best popular exposition of the arcana of cast iron metallurgy.

# Combined Alternating Stresses.

## THE INSTITUTION OF MECHANICAL ENGINEERS.

THE study of the behaviour of metals under stress has so far produced an extensive amount of information under three headings namely information relating to the behaviour of metals (*a*) when subjected to *static* tensile, compressive bending, torsional or shear stress (*b*) when subjected under *static* conditions to a *combination* of any two of these forms of stress and (*c*) when subjected to a *cyclic variation* of any *one* of the stresses. Two other headings are of importance in practice namely the behaviour of metals (*d*) when subjected to a *static* stress of any one of the forms named in combination with a *cyclic variation* of any one of the other stresses and (*e*) when subjected to a *cyclic variation* of any one stress in combination with a *cyclic variation* of any one of the other stresses. A limited amount of information is available under heading (*d*), the combinations investigated being in two cases static torsion superimposed on cyclic bending and in one case static tension superimposed on cyclic torsion. Under heading (*e*) one investigation has been carried out, the combination studied having been cyclic torsion with cyclic bending. The field open for study under this last heading (*e*) is very extensive. It covers not only the multiplicity of combinations of the different stress forms taken two at a time but also, in any one combination, the effect produced by a variation in phase of the two applied cyclic stresses. In the one investigation mentioned as having been carried out under heading (*e*) the applied cyclic stresses were in phase with each other. No experiments have so far been made on the effect of phase variation.

The object of the paper presented on Friday evening November 1st before the Institution of Mechanical Engineers by Dr. H. J. Gough and Mr. H. V. Pollard was to extend the information available under heading (*e*). The precise conditions investigated by the authors consisted of cyclic bending combined, in phase, with cyclic torsion. The practical importance of this combination arises from the fact that it is the combination encountered in engine crank shafts. The particular combination of stresses having been selected, the field of investigation had to be farther narrowed. In an ordinary fatigue test two independent variables have to be considered in connection with the applied stress namely the range covered by the cyclic variation and the situation of the mean value of the range. In a "direct" stress fatigue test, for example, the cycle of stress might extend from $-10$ tons (compression) to $+10$ tons (tension) or from zero to 20 tons or from 5 tons tension to 25 tons tension. In each case the range is 20 tons but the mean stress values are 0, 10 and 15 tons respectively. A test involving the combination of two cyclic stresses permits in this respect a wide choice of conditions determined by the values selected for these two independent variables for each of the stresses.

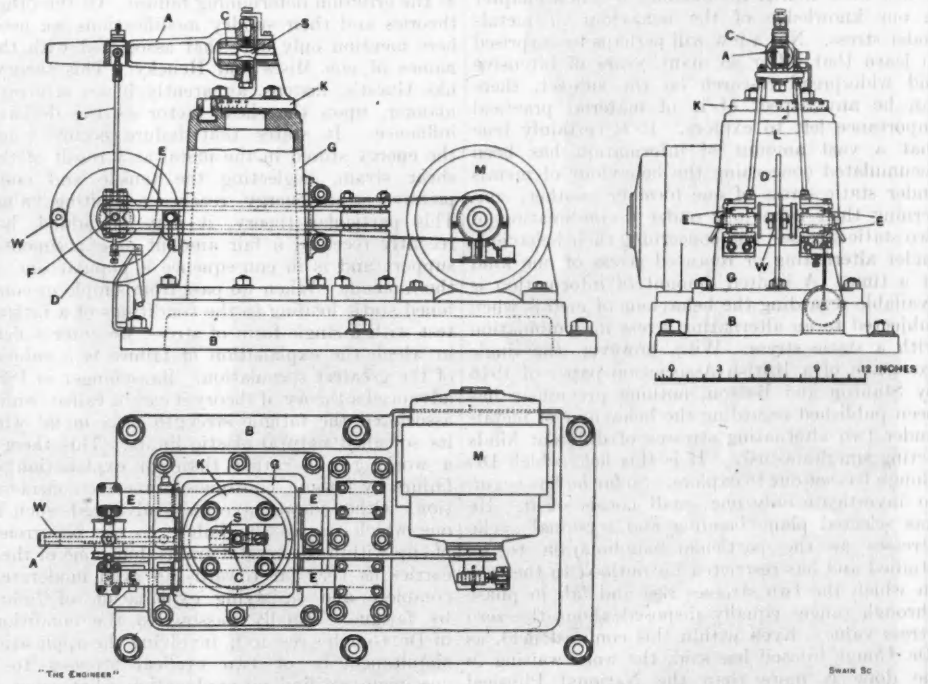



FIG. 1—N.P.L. COMBINED STRESS FATIGUE TESTING MACHINE

Dr. Gough and Mr. Pollard decided in the first instance to restrict their investigation to the condition in which the mean value of both the cyclic stresses was zero. The investigation therefore covered a study of the behaviour of metals when subjected to a bending stress varying from $+f$ to $-f$ in combination with a torsional stress varying from $+q$ to $-q$, the zero value of the one range occurring simultaneously with the zero value of the other.

The research is not yet completed. It is planned to cover some fourteen types of steel and three types of cast iron. The paper presents the results so far obtained from a mild steel, a heat treated alloy steel and a cast iron. Each material has been subjected to seven different combinations of bending and torsional stress ranging from all bending and no torsional stress to all torsional and no bending stress.

The machine on which the tests were conducted is shown in Fig. 1. The specimen S is held at one end in a bracket K clamped on top of the pedestal G. The other end of the specimen is held in a collar C to which an arm A is pivoted on an axis aligned vertically with the centre of the specimen. A disc D carrying an out-of-balance weight W is supported on an axle F fixed to the ends of springs E, the other ends of which are fixed to a bracket on the base-plate of the machine. A motor M running at 1500 r.p.m. drives the disc through a belt. The bracket carrying the axle F is connected by links L to the centre of percussion of the arm A. In this manner the out-of-balance force developed at the axle of the disc is transmitted as an alternating moment to the arm A and thence to the specimen. If the specimen and the bracket K are aligned as shown in the engraving the moment applied to the specimen will be one of pure bending. If the specimen and bracket are turned through 90 deg. the applied moment will be one of pure torsion. At intermediate angles the specimen will be subjected partly to a bending and partly to a torsional moment, the bending moment being proportional to cos θ and the torsional moment to sin θ. The two moments are in phase and reach their maximum and minimum values simultaneously. By varying the ratio of the belt pulley diameters the speed of the disc is adjusted to the frequency of resonance of all the parts vibrating on the ends of the springs E with the object of eliminating all the inertia forces except those arising from the out-of-balance weight. With such other inertia forces eliminated the value of the moment applied to the specimen can be determined directly from the mass of the out-of-balance weight and the speed of rotation of the disc. A direct calibration was applied as a check and was found to be in excellent agreement with the deduced value. By means of only six different out-of-balance weights ranges of bending stress from $\pm 5$ tons to $\pm 50$ tons per square inch with intermediate steps of $\pm \frac{1}{2}$ ton per square inch can be obtained, the specimens being of a standard 0·3in. diameter. The out-of-balance weights not in use during any test are mounted on the arm A over the centre line of the links L in order that the mean weight distribution of the moving parts may be preserved constant in all the tests.

The three materials on which tests have so far been completed are 0·1 per cent. carbon steel in the normalised condition, 3½ per cent. nickel-chromium steel in the hardened and tempered condition and "Silal" iron in the "as-cast" condition. The specimens were solid. At a later stage it is proposed to use hollow specimens for comparative purposes and also in order to permit the tests to be conducted with the specimens subjected to an internal pressure. For each material the fatigue limit was determined with the specimen set relatively to the arm at A angles of 0, 15, 30, 45, 60, 75 and 90 deg. The extreme values correspond to pure bending and pure

torsion respectively. The intermediate values correspond to ratios of twisting moments to bending moments of 0·268, 0·577, 1·0, 1·732 and 3·732.

In addition to the combined cyclical stress tests carried out on the machine illustrated in Fig. 1 each material was tested for its static tensile and torsional strengths separately, for its impact strength on an Izod machine, for its bending fatigue limit on a rotating bar machine of the Wöhler type and for its torsional fatigue limit on a Stromeyer machine. Concerning these supplementary tests it is sufficient to say that the two steels gave results on the Stromeyer

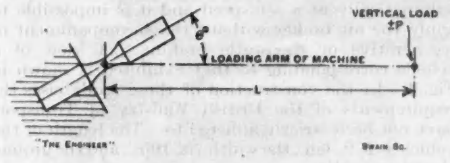



FIG. 2—LOADING DIAGRAM

machine agreeing to within 1 or 2 per cent. with their fatigue limits as determined on the combined stress machine when that machine was set to apply a pure torsional moment to the specimen (θ=90 deg.). With the combined stress machine set to apply a pure bending moment to the specimen (θ=0 deg.) the fatigue limits for the two steels agreed to within 2 or 4 per cent. with those given on the Wöhler machine. The comparative figures for the "Silal" cast iron showed less close agreement but they may have been influenced by variations in the uniformity of the metal.

Passing to a description of the main results of the research we would refer to Fig. 2 in which a diagram of the loading system of the combined stress machine is given. The vertical load ±P acting at the end of the loading arm of length L applies to the specimen a moment M varying from +P L to −P L. The angle θ being neither zero nor 90 deg. this moment is resisted partly by the bending strength of the metal and in part by its torsional strength, the distribution being M cos θ with respect to bending and M sin θ as regards torsion. The bending moment if it acted by

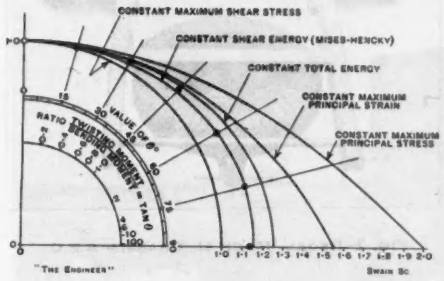



FIG. 3—RESULTS. 0·1 PER CENT. CARBON STEEL

itself on the specimen would induce in it a maximum tensile or compressive stress of amount $f = K M \cos\theta$. The torsional moment by itself would induce a maximum shearing stress in the specimen of amount $q = \frac{1}{2} K M \sin\theta$. In these expressions the quantity K is equal to $32/\pi d^3$, where $d$ is the diameter of the specimen and is therefore a constant for specimens of equal diameter. The two stresses acting together combine to induce in the specimen a principal tensile stress, $p_1 = \frac{1}{2} K M (1+\cos\theta)$ a principal compressive stress, $p_2 = \frac{1}{2} K M (1-\cos\theta)$ and a maximum shear stress $S = \frac{1}{2} K M$.

In the accompanying table the results of the research on the three metals are summarised. In order to make this table quite clear we will run through its second line. This line refers to the mild steel material with the specimen set at 15 deg. relatively to the loading arm. At this setting the total moment M is supported to the extent 0·259 M by the torsional resistance of the specimen and to the extent 0·969 M by its bending resistance, the ratio of these quantities being 0·268. At this setting successive specimens were tested to failure, each test being carried out at a less

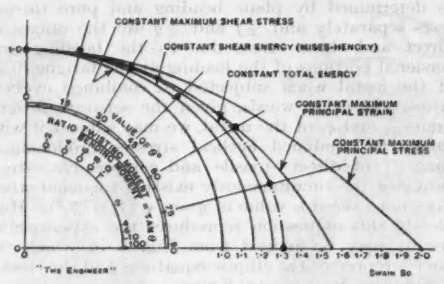



FIG. 4—RESULTS. 3½ PER CENT. NI-CR. STEEL

load, P, than the test preceding it. The tests were continued until a loading was reached at which the specimen would just not fail after an indefinite number of repetitions of the stress cycle. This loading, in the case being considered, was found to be such that the portion of it resisted by the bending strength of the specimen would, if it acted alone, induce in the metal a maximum range of stress extending from 17·0 tons per square inch in tension to a like figure in compression. The portion of the loading resisted by the shearing strength of the specimen would similarly, if it acted alone, induce in the metal a maximum range of shearing stress extending from 2·3 tons per square inch in one direction to a like amount in the other. Acting together, the two portions of the critical loading induced a stress distribution which at one moment exhibited a maximum tension of 17·3 tons accompanied by a maximum compression of 0·3 ton and at another a maximum compression of 17·3 tons accompanied by a maximum tension of 0·3 ton. Simultaneously with these tensile and compressive stresses the specimen had to withstand a shear stress, arising from the combined effects of the two portions of the loading, ranging from 8·8 tons in one direction to a like figure in the other.

*Summary of Combined Stress Fatigue Experiments.*

| Material | Value of θ, deg. | Ratio of applied twisting moment to bending moment (tan θ). | Fatigue limits, tons per square inch. Range of direct stress due to bending $f$, tons per sq. in. | Range of shear stress due to torsion $q$, tons per sq. in. | Ranges of principal stresses. $p_1$ (tension). Value. | $p_1$ (tension). Ratio. | $p_2$ (compression) | Range of maximum shear stress S. Value. | Ratio S/S₀. |
|---|---|---|---|---|---|---|---|---|---|
| 0·1 per cent. carbon steel | 0 | 0 | ±17·4 | 0 | ±17·4 | 1·00 | 0 | ± 8·7 | 1·00 |
| | 15 | 0·268 | ±17·0 | ± 2·3 | ±17·3 | 0·99₅ | ± 0·3 | ± 8·8 | 1·01 |
| | 30 | 0·577 | ±15·7₅ | ± 4·5₅ | ±17·0 | 0·98 | ± 1·2 | ± 9·1 | 1·04₅ |
| | 45 | 1·000 | ±13·3₅ | ± 6·7 | ±16·1 | 0·92₅ | ± 2·8 | ± 9·4₅ | 1·08₅ |
| | 60 | 1·732 | ± 9·5₅ | ± 8·2₅ | ±14·3 | 0·82 | ± 4·8 | ± 9·5₅ | 1·10 |
| | 75 | 3·732 | ± 5·1 | ± 9·5₅ | ±12·5 | 0·72 | ± 7·3 | ± 9·9 | 1·14 |
| | 90 | ∞ | 0 | ± 9·8₅ | ± 9·8₅ | 0·56₅ | ± 9·8₅ | ± 9·8₅ | 1·13 |
| 3½ per cent. nickel-chromium steel | 0 | 0 | ±35·0 | 0 | ±35·0 | 1·00 | 0 | ±17·5 | 1·00 |
| | 15 | 0·268 | ±34·9₅ | ± 4·6₅ | ±35·6 | 1·02 | ± 0·6 | ±18·1 | 1·03₅ |
| | 30 | 0·577 | ±31·8₅ | ± 9·2 | ±34·3 | 0·98 | ± 2·5 | ±18·4 | 1·05 |
| | 45 | 1·000 | ±26·6 | ±13·3 | ±32·1 | 0·92 | ± 5·5 | ±18·8 | 1·07₅ |
| | 60 | 1·732 | ±21·3 | ±18·4₅ | ±31·9 | 0·91 | ±10·7 | ±21·3 | 1·21₅ |
| | 75 | 3·732 | ±11·6 | ±21·6 | ±28·2 | 0·81 | ±16·6 | ±22·4 | 1·28 |
| | 90 | ∞ | 0 | ±22·8 | ±22·8 | 0·65 | ±22·8 | ±22·8 | 1·30₅ |
| "Silal" cast iron | 0 | 0 | ±15·6 (14·8) | 0 | ±15·6 (14·8) | 1·00 | 0 | ± 7·8 (7·4) | 1·00 (1·00) |
| | 15 | 0·268 | ±15·2₅ | ± 2·0₅ | ±15·5 | 0·99₅ | ± 0·3 | ± 7·9 | 1·01₅ (1·07) |
| | 30 | 0·577 | ±13·6 | ± 3·9₅ | ±14·6 | 0·93₅ | ± 1·1 | ± 7·8₅ | 1·00₅ (1·06) |
| | 45 | 1·000 | ±12·6 | ± 6·3 | ±15·2 | 0·97₅ | ± 2·6 | ± 8·9 | 1·14 (1·20₅) |
| | 60 | 1·732 | ± 9·9 | ± 8·6 | ±14·9 | 0·95₅ | ± 4·9 | ± 9·9 | 1·27 (1·34) |
| | 75 | 3·732 | ± 5·8 | ±10·8 | ±14·1 | 0·90₅ | ± 8·3 | ±11·2 | 1·43₅ (1·51₅) |
| | 90 | ∞ | 0 | ±14·2 (13·5) | ±14·2 (13·5) | 0·91 | ±14·2 | ±14·2 (13·5) | 1·82 (1·92) (1·82₅) |

The designation of the stresses $p_1$ and $p_2$ as tension and compression respectively is for convenience only and is derived from the practice followed in static testing. Both actually fluctuate between tension and compression. When $p_1$ reaches its maximum tensile value, $p_2$ has its maximum compressive value and *vice versâ*.

The first column headed "ratio" in the table gives the value of $p_1$ at any angular setting θ of the specimens relatively to the value of $p_1$ when θ is zero. The second ratio column gives the value of the shearing stress S at any angular setting relatively to the shearing stress $S_0$ when θ is zero.

The figures within brackets in the case of the "Silal" cast iron indicate alternative results and are measures of the uncertainty existing in connection with this particular material.

The important point to discover from the figures given in the table is the answer to the question: What factor or what combination of factors causes a metal to fail when it is subjected to combined bending and torsional cyclical stresses? Did the mild steel specimens at 15 deg. fail because the loadings to which they were subjected induced a maximum tension greater than 17·3 tons, or because they had to bear a maximum compression in excess of 17·3 tons or because the shear stress which they were called upon to withstand covered a greater range than ±8·8 tons?

For guidance in the analysis of their results the authors turned to the various theories which have been propounded to explain the cause of failure of metals when subjected to a combination of *static* stresses, although there is no *a priori* reason why static conditions should have the same criterion of failure as kinetic conditions.

The first theory of failure under combined static stress is that known as Guest's law. This, the maximum shear theory, states that failure occurs by virtue of the fact that the maximum shear induced by the combined loading exceeds the ultimate shearing strength of the metal. If a corresponding law held for combined cyclical stress the ratio $S/S_0$ in the last column of the table would be unity.

The second theory, the maximum stress theory, postulates that failure occurs by virtue of the value of the maximum principal stress. In this case the column in the table headed $p_1$ should exhibit a constant value for each of the three metals.

Thirdly, there is St. Venant's theory which states that failure is determined by the maximum principal strain exceeding a limiting value. The maximum principal strain is a function of the stresses $p_1$ and $p_2$ of Young's modulus E and of Poisson's ratio σ. The table as it stands does not enable us to say whether this theory is or is not applicable to kinetic conditions.

A fourth theory, due to Beltrami, states that failure occurs when the total elastic strain energy in unit volume of the material exceeds a certain limiting value. The expression for this energy is not included in the table. It is a complex function of $p_1$, $p_2$, E and σ.

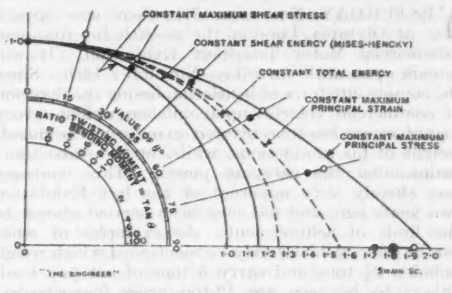



FIG. 5—RESULTS. "SILAL" CAST IRON

Finally the von Mises-Hencky theory states that failure occurs when the energy corresponding to the shear strain, excluding the energy due to the tensile and compressive strains, exceeds a limiting value. In this case a certain function of $p_1$ and $p_2$ should be constant for each metal.

Since the maximum shear stress S is related to the principal stresses $p_1$ and $p_2$ by the relationship $S = \frac{1}{2}(p_1 - p_2)$ it is possible to transform the criteria of these five theories on to a common basis for purposes of comparison among themselves and with the actual results yielded by the experiments. As a result of this transformation each of the criteria reduces to an expression for S in terms of $S_0$ and of θ, the angle of setting of the specimen, and, in two cases, of Poisson's ratio σ. The five transformed criteria are as follows:—

*Maximum Shear Theory:*

$$S = S_0$$

*Maximum Principal Stress Theory:*

$$S = 2\,S_0/(1+\cos\theta)$$

*Maximum Principal Strain Theory:*

$$S = \frac{2\,S_0}{(1+\sigma)+(1-\sigma)\cos\theta}$$

*Constant Total Energy Theory:*

$$S = \frac{\sqrt{2}\,S_0}{\sqrt{\{1+\sigma+(1-\sigma)\cos^2\theta\}}}$$

*Constant Shear Energy Theory:*

$$S = \frac{2\,S_0}{\sqrt{(3+\cos^2\theta)}}$$

Taking the value of Poisson's ratio at 0·284 for all three metals, the authors by means of these expressions constructed polar diagrams showing what value the ratio $S/S_0$ should have at different values of θ according to each of the five theories. These diagrams for the three metals are shown in Figs. 3, 4, and 5. The black—or white—dots represent the values of $S/S_0$ actual determined by the experiments.

It will be seen that in the case of the mild steel, Fig. 3, the experimental points fall almost exactly as they should if the constant shear energy theory of Mises and Hencky were true. For the nickel-chromium steel, Fig. 4, however, the experimental points are in closest agreement with Beltrami's constant total energy theory. For the "Silal" cast iron the experimental points conform reasonably closely to the maximum principal stress theory.

For the time being and until the research is carried farther the authors do not consider it desirable to

discuss the difference of behaviour thus revealed by the three metals. The fact that no one of the five

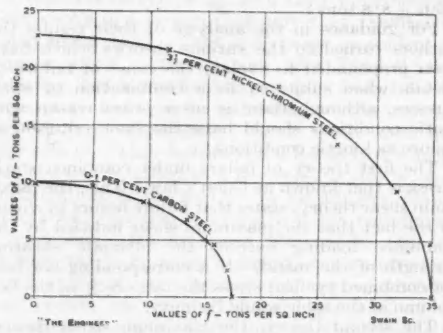

3½ PER CENT NICKEL CHROMIUM STEEL
0·1 PER CENT CARBON STEEL
VALUES OF f — TONS PER SQ INCH
VALUES OF f1 — TONS PER SQ INCH
"THE ENGINEER"
SWAIN Sc.

FIG. 6—ELLIPTIC CURVES FOR STEEL

theories appears to be generally applicable does not invalidate the possibility that some rational theory may be found to cover the results. Meanwhile noting the fact that the results obtained from the two steels Figs. 3 and 4 fall on elliptical curves the authors have devised an empirical formula which closely expresses them although no definite physical meaning can at present be assigned to it. This formula is

$$f^2/f_1^2+q^2/q_1^2=1,$$

where $\pm f_1$ and $\pm q_1$ are the fatigue ranges of the metal as determined by plane bending and pure torsion tests separately and $\pm f$ and $\pm q$ are the ranges of direct and shear stress due to the bending and torsional portions of the loading at the fatigue limit of the metal when subjected to combined cyclical stress. In other words, given the separate fatigue limits $f_1$ and $q_1$ of the metal, we may subject it with safety to combined cyclical stresses producing a range $f$ of direct—tensile and compressive—stress provided the simultaneously existing torsional stress does not exceed a value of $q=q_1\sqrt{(1-f^2/f_1^2)}$. How closely this expression reproduces the experimental results may be judged from Fig. 6 in which the curves represent the elliptic equations and the crosses denote the experimental figures.

# Commercial Motor Transport Exhibition.

No. I.

YESTERDAY, November 7th, there was opened at Olympia, London, the twelfth International Commercial Motor Transport Exhibition. It will remain open until Saturday, November 16th. Since the coming into force of legislation basing the taxation of commercial vehicles upon unladen weight, every manufacturer has concentrated on reducing the chassis weight of his productions, while, at the same time, maintaining the carrying power. This tendency was already very apparent at the last Exhibition two years ago, and has now been carried almost to the limit of achievement. As examples of what can be done, vehicles may be mentioned which weigh unladen 2½ tons and carry 5 tons of net pay load. Others to be seen are 12-ton gross four-wheelers with a pay load of as much as 8 tons, and 22-ton gross eight-wheelers with a 16-ton capacity. Two years ago only one manufacturer was making the last-named rigid type of vehicle, but this year several different makes are to be found. It is justifiably claimed for these great lorries that, despite the fact that steering must take place on four wheels, the action is as light as that of the ordinary car. Perhaps it is as a result of restrictions upon the use of horse-drawn vehicles and the suspicion that further restrictions will be enforced in the not far distant future that the mechanical horse, three-wheeled tractor is coming more and more into prominence. This type of equipment combines all the manœuvrability of the horse with greater speed and as much convenience. As the law limits the overall length of any vehicle, one of the problems with this class of tractor-trailer equipment is that of coupling the trailer as

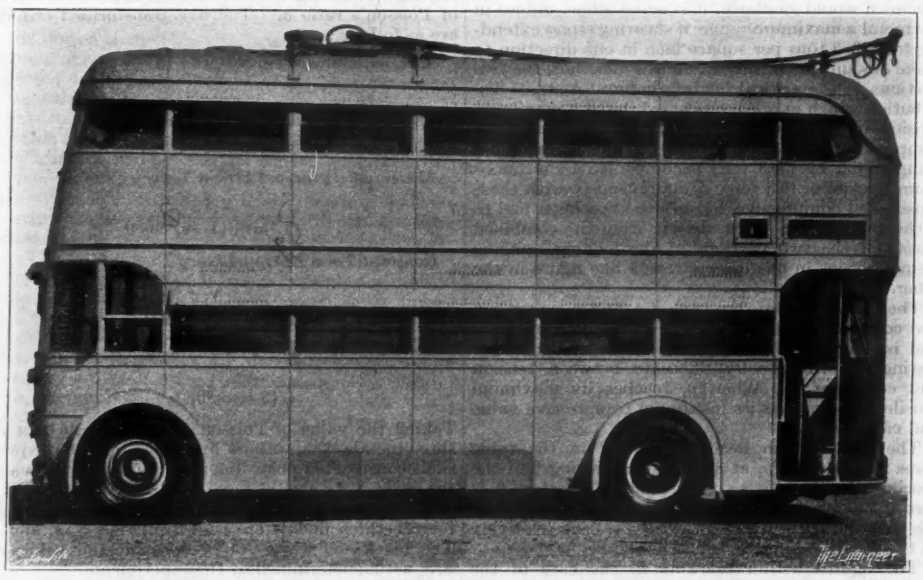


FIG. 1—80 B.H.P. DOUBLE-DECK TROLLYBUS—RANSOMES

closely as possible to the driver's cab without interfering with the clearance necessary for turning a sharp corner. In one vehicle of this type exhibited the coupling allows the trailer to "slip" back when a corner is turned and draws it into close engagement again on the straight. In trailers, of course, the two most troublesome problems have been that of overcoming "weaving," and the provision of adequate brakes. Both appear to have been successfully dealt with. As far as vehicle bodywork is concerned, here, too, the main line of development is towards a lightening of the structure. But the importance of a good appearance is not being overlooked, while the comfort of the driver is now carefully studied. A less important trend is that towards fitting to the smaller vans roller shutters instead of doors. Moving floors, too, seem to be coming into greater favour. Besides the ordinary commercial lorries and buses there are to be seen tank wagons, ambulances, fire-engines, taxicabs, and numerous vehicles for special purposes, such as the repair of tramway overhead equipment.

On the purely mechanical side there is little that is "revolutionary" in character. Some new oil engines are exhibited, most of which will be described in our articles on the Exhibition. Braking equipment shows some minor changes, and the use of "fluid" transmission systems of one kind or another appears to be increasing. Readers, however, will be able to gain their own impressions on such points from the articles which we publish in this issue and will continue to publish in following issues.

### RANSOMES, SIMS AND JEFFERIES, LTD.

One of the Ransomes 62-seater all-metal body trollybuses being supplied to Cape Town is shown by Ransomes, Sims and Jefferies, Ltd., of Ipswich. The chassis conforms with the maker's standard practice. A Ransomes-Garrett patented floating tubular propeller shaft, claimed to eliminate whipping and vibration and to reduce wear on the joints to a negligible quantity, transmits the power to the back axle, which is of the maker's latest design. Internal expanding brakes act on the front and rear wheels. The air brake equipment includes a Reavell compressor driven by a Ransomes motor, both electrically and mechanically insulated from the chassis.

The all-metal body, made by Weymanns Motor Bodies (1925), Ltd., calls for low-tension lighting current, which is supplied by a small motor generator set. Like the compressor unit, it is electrically and mechanically insulated from the chassis frame to avoid electrical leakage and to minimise vibration and noise. By reason of the arduous service conditions in Cape Town, the main Ransomes driving motor is rather larger than usual, for the rated output of 80 b.h.p. Braking on the regenerative and rheostatic principles is provided for by the Ransomes patented system of control operated by the same pedal as that which applies the air brakes. Change over from regenerative to rheostatic braking takes place automatically at a set speed and it is impossible to apply the air brakes without the accompaniment of regenerative or rheostatic braking. A view of a vehicle corresponding to that exhibited is shown in Fig. 1. In the construction of these trollybuses the requirements of the British Ministry of Transport have not been strictly adhered to. The length of the vehicle is 27ft. 6in., the width 7ft. 10in., and the ground clearance is 8½in.

An electrically operated brake unit exhibited has been introduced to enable brakes to be operated with electric power instead of compressed air. It can draw its supply from the overhead trolly wire or from the low-tension battery, which always forms part of the equipment of trollybuses. The unit consists of an electric motor which rotates a worm in constant mesh with a worm wheel, coupled to the brake-operating lever by a clutch. When the brake is applied by depressing the foot pedal the clutch is thrown in and the motor is started. This rotates the worm wheel and the brake-operating lever. The motor then comes to rest, but continues to exert a torque. Subsequent depression of the pedal cuts out resistance in series with the motor, which then exerts its maximum torque. Further depression of the pedal increases the pull by physical force. On releasing the pedal the current to the motor is interrupted and the clutch is disengaged. The clutch provides a positive drive and does not rely on friction surfaces for the transmission of the braking effort.

A 2-ton electric truck exhibited represents the firm's latest design. It is an elevating platform truck with a low loading line. The driving motor is a totally enclosed series-wound machine, and is mounted on the axle case between the front wheels. The foot-operated controller has safety interlocks, which avoid the possibility of switching on the current and applying the brakes simultaneously. Unless the controller—which gives four speeds in either direction—is first

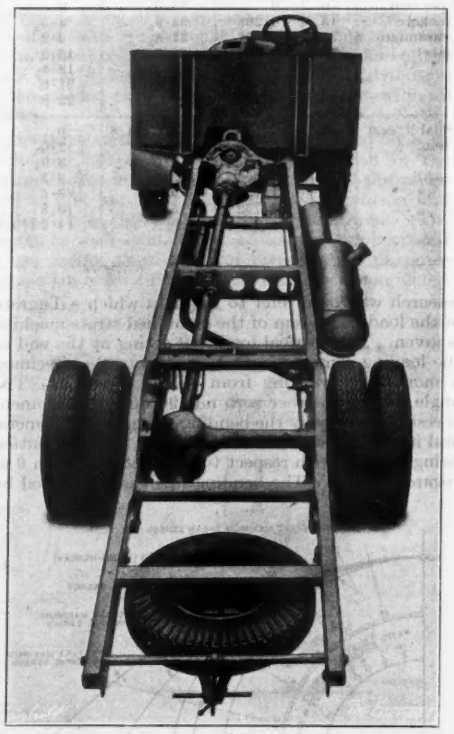


FIG. 2—REGAL MARK II CHASSIS—A.E.C.

placed in the neutral position, it is impossible for the truck to be started in either direction, whilst in the event of the driver leaving the platform the power is automatically cut off and the brakes applied. Although the tiller steering system on the vehicle exhibited acts on the four wheels, all these trucks for use in restricted areas can be fitted with two-wheel steering gear. The large reserve of the motor power can be gauged from the fact that a truck corresponding to that exhibited has carried its full load up a gradient of 1 in 5. High platform elevating trucks and low fixed platform trucks are also made.

### THE ASSOCIATED EQUIPMENT COMPANY, LTD.

On the stand taken by the Associated Equipment Company, Ltd., of Southall, Middlesex, a number of buses, coaches, lorries, trollybuses, and engines are

to be seen. The new "Regal" Mark II, the chassis of which is illustrated in Fig. 2, is likely to attract the most attention. It is shown with a double-deck bus body. Naturally, the best features of its prototype have been retained. As will be seen from the engraving, deep-section steel is used for the 11in. frame of low loading height, which is upswept over the front and rear axles. An electrical control unit is mounted in an accessible position in the driver's cab. Hydraulic brakes are operated by a vacuum servo on each axle, and it is interesting to observe that the front axle king pins are used as the operating cylinder for the front brakes. The servo and hydraulic master cylinder are built as one unit. The usual rotary exhauster is not to be found. Vacuum for the brake servo is obtained from the induction pipe of the engine. Directly connected to the brake pedal there is a butterfly valve which ensures that vacuum is obtained whenever the brake is applied. To comply with the regulations there is a vacuum reservoir connected to the induction system through a non-return valve. Brake linings are ¾in. thick. The most important modification made is that of fitting a new oil engine developing 100 b.h.p. in six cylinders having a bore of 105 mm. and a stroke of 130 mm. This unit, which is illustrated in Fig. 3, weighs only 1145 lb., including such auxiliaries as the dynamo and starter. It has a Ricardo "Comet" combustion head. Overhead valves are operated by push-rods from the cam shaft, which is carried in the crank case. The latter is in one piece with the cylinder block. Wet liners are fitted and can be detached and replaced without removing the engine from the chassis. The four-speed gear-box is mounted, as is usual nowadays, as a unit with the engine, and has a "constant mesh" third speed, whilst the single-plate clutch, which has 360 square inches of wearing surface, is fitted with an adjustable clutch stop. The final drive to the axle is through an underslung worm.

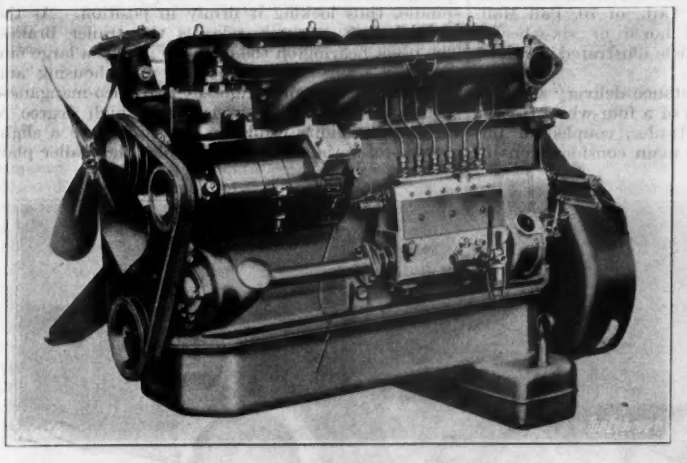


FIG. 3—100 H.P. OIL ENGINE—A.E.C.

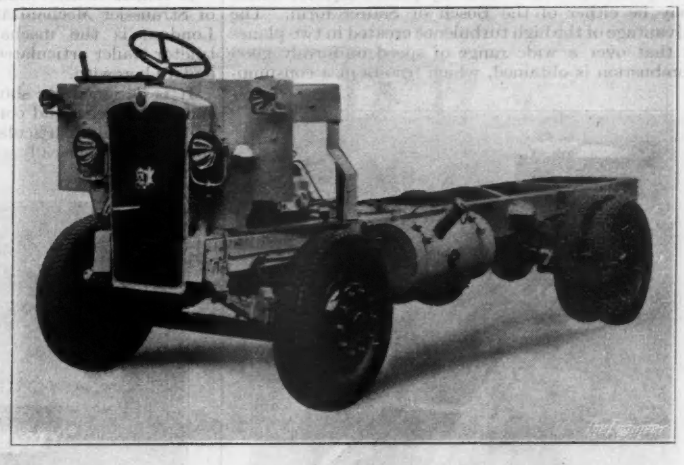


FIG. 4—7-TON LORRY CHASSIS—CROSSLEY

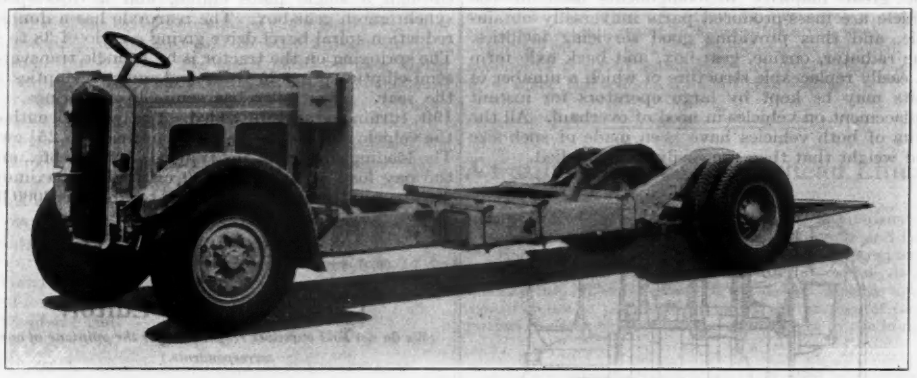


FIG. 5—DOUBLE-DECK OMNIBUS CHASSIS—CROSSLEY

### CROSSLEY MOTORS, LTD.

From the wide range of passenger and goods vehicles exhibited by Crossley Motors, Ltd., of Gorton, Manchester, we have chosen for illustration the new double-deck chassis, equipped with a Crossley oil engine and a flexible converter with the Freeborn automatic gear. A general view of this chassis is reproduced in Fig. 5, which shows the deep frame members and the low slinging of the chassis. The rear axle is of the full floating type with an underdriven worm gear and bevel type differential. The foot brake operates on all four wheels, and is assisted by a servo-attachment, which comprises one main cylinder for the rear wheels and two auxiliary cylinders for the front wheels. One set of wide shoes is fitted to the rear wheels, and is operated by hand or foot. Disc type wheels are fitted and they carry 9·75in. by 20in. single tires on the front and 9·0in. by 20in. twin tires on the rear. The wheelbase is 16ft. 7½in., with a front track width of 6ft. 3⅝in., and a rear track width of 5ft. 10¼in. Electric lighting and starting is fitted.

The engine is of the latest Crossley VR 6 type, incorporating the Ricardo patented swirl chamber. The six cylinders have a bore of 4 7/16 in. and a stroke of 6in. with a capacity of 9120 c.c. and a Treasury rating of 47·3 h.p. The overhead valves are entirely enclosed and the lubrication and water cooling is effected by engine-driven pumps. The Bosch fuel pump and injector system is fitted and the fuel is delivered to the fuel pump by an Autovac system.

Particular interest attaches to the completely automatic gear-box, which dispenses with all manual gear changing, and by the use of a flexible converter enables the vehicle to be driven on the accelerator and brake pedals only. We hope to deal with this gear fully in a later article. Alongside the chassis above described there is a double-deck omnibus of patented all-steel construction, with a 56-seat arrangement and enclosed staircase. In this vehicle an orthodox four-speed gear-box is provided.

Another interesting chassis—see Fig. 4—is the Crossley B.E.T.A., 7-ton goods-carrying lorry, which is also equipped with a Crossley-Ricardo oil engine. Forward steering is fitted and there is an eight-speed Duplex gear-box. The rear axle drive and the brake gear is generally similar to that already described, and the disc wheels carry 36in. by 8in. giant pneumatic tires with single tires on the front and twin tires on the rear. The wheelbase is 12ft. 6in., and the chassis is fitted with a driving cab and a drop-sided lorry body.

### ARMSTRONG-SAURER.

On the stand of Armstrong-Saurer Commercial Vehicles, Ltd., of Scotswood, Newcastle-upon-Tyne, and Brentford, Middlesex, there are shown a number of examples of the new Armstrong-Saurer engine, embodying the dual turbulence principle of combustion with airless injection of fuel. In Fig. 9 we show a typical section through the engine, which in its six-cylinder form is fitted to three of the different chassis on view. The dual turbulence principle is designed to produce ordered turbulence in the air stream in both horizontal and vertical planes. An initial horizontal whirling motion is obtained by the use of a shrouded inlet valve, which in conjunction with the rising motion of the piston produces a rotary

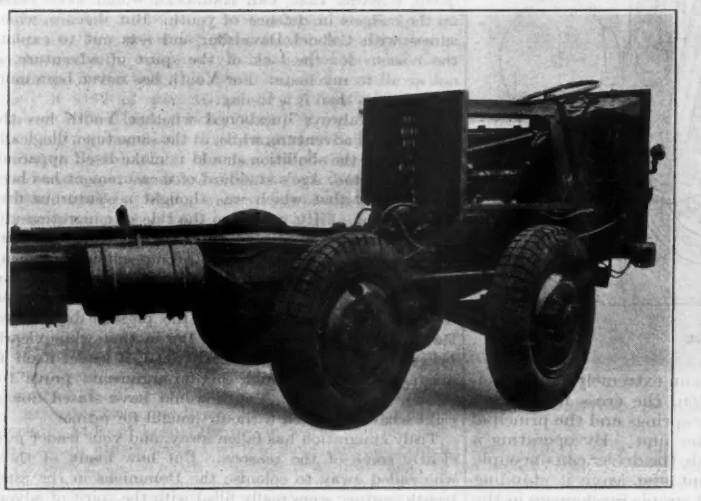


FIG. 6—STEERING AXLES OF EIGHT-WHEELER—ARMSTRONG

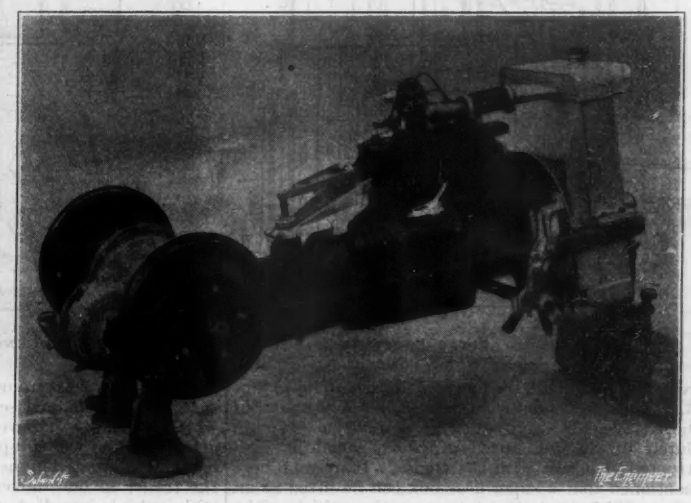


FIG. 7—POWER UNIT OF TRACTOR—STRAUSSLER

swirl during the compression stroke. In addition, a heart-shaped chamber formed in the crown of the piston causes this swirl to take a change of direction, which produces a superimposed vertical swirl. The horizontal whirling motion is controlled by the setting of a shroud on the inlet valves, which are two in number and small in diameter, and are arranged to suit the cylinder diameter. Two exhaust valves are also provided with a centrally placed injector which may be either of the Bosch or Saurer form. The advantage of the high turbulence created in two planes is that over a wide range of speed uniformly good combustion is obtained, which results in a consumption of about 0·385 lb. per b.h.p. hour under full-load running conditions.

FIG. 8—RIGID EIGHT-WHEELER—ARMSTRONG

The six-cylinder standard engines all have a bore of 110 mm., with a stroke of 150 mm., and a Treasury rating of 45 b.h.p. In addition to the three engines, there is a larger six-cylinder one which has been specially designed for heavy duty overseas service. It has a bore of 130 mm. with a stroke of 180 mm., and a Treasury rating of 63 h.p. Two smaller four-cylinder engines are also shown. A new exhibit at Olympia is the Samson type rigid eight-wheel chassis with forward control, which we illustrate in Figs. 6 and 8. It consists, as the engravings show, of two front axles, both equipped with steering gear, along with a live third axle and a trailing fourth axle. The 45 h.p. R.A.C. rating engine is suspended at three points in the chassis. It drives through a multiple dryplate clutch to the four-speed gear-box, which is constructed as a unit with the engine. It may be here mentioned that a super gear-box can be fitted as an extra, which is designed to give the vehicle eight forward speeds. A central change is provided on the main gear-box, while the super gear is changed semi-automatically. The driving axle is of the fully floating type and a special reduction gear can be fitted if required.

The braking system is designed to work with compressed air and to operate on all wheels. A take-off for tire-pumping can be provided. The tires are 36in. by 8in. Dunlop pattern. The 24-volt starter has a designed output of 6 b.h.p., and is operated by two 12-volt, 180-ampère-hour batteries. The lighting system is also 24 volts with a 300-watt dynamo output.

STRAUSSLER MECHANIZATION, LTD.

A vehicle of more than usual interest on the stand of Straussler Mechanization, Ltd., of 70, Pall Mall, London, is the mechanical horse or six-wheeled tractor-trailer articulated vehicle illustrated in Figs. 7 and 10 herewith.

It is designed for short-distance delivery work in congested areas, and consists of a four-wheel tractor and detachable articulated trailer, coupled or uncoupled automatically. The main considerations in producing this vehicle were a low-priced unit as an alternative to horse-drawn vehicles, with an extremely simply lay-out for easy accessibility and low cost of maintenance, coupled with economy of operation. The great majority of components used in the vehicle are mass-produced parts universally obtainable, and thus providing good servicing facilities. The radiator, engine, gear-box, and back axle form an easily replaceable structure of which a number of units may be kept by large operators for instant replacement on vehicles in need of overhaul. All the units of both vehicles have been made of such size and weight that they are easily man-handled.

FIG. 10—TRACTOR-TRAILER ARTICULATED VEHICLE—STRAUSSLER

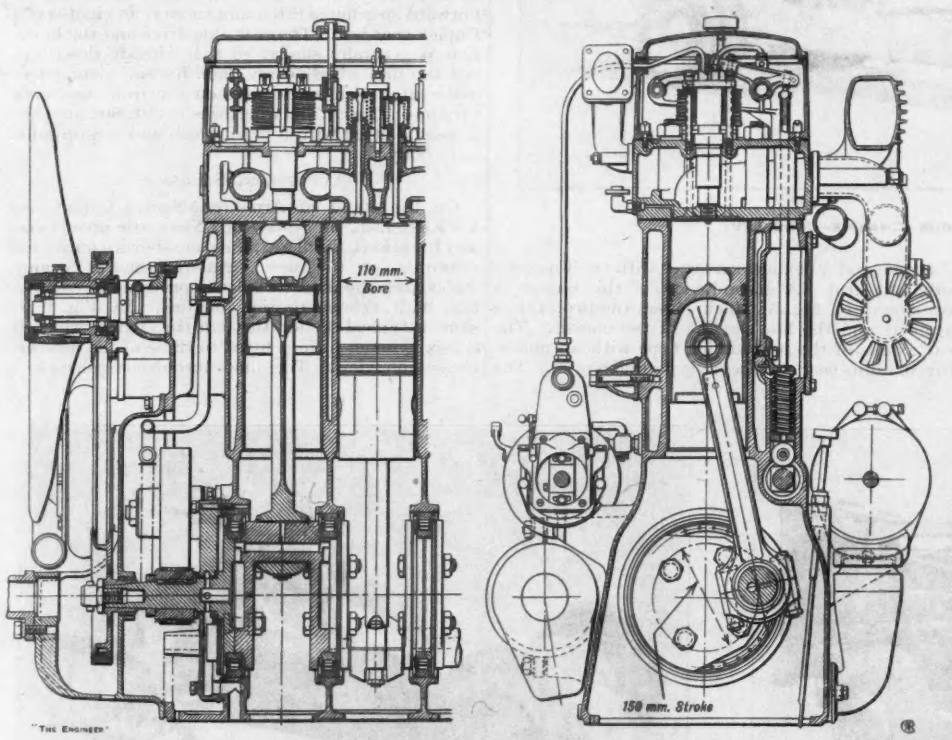



FIG. 9—SECTIONS THROUGH ARMSTRONG-SAURER ENGINE

The main tractor frame is an extremely rigid structure of deep channel section, the cross member of which carries the transverse springs and the principal attachment of the sub-power unit. By operating a hand lever situated in the cab, the driver can uncouple the trailer in one movement and leave it standing with its brakes applied, as a simple mechanism in the coupling unit automatically applies the brakes on the trailer at the instant of decoupling. When disconnected, another hand lever on the front of the trailer can be used to take the brakes off if it is desired to move it. The trailer can then be easily moved to any position, as its forward end is fitted with roller bearing rubber tired castors of generous dimensions. In coupling the trailer at any angle, it is only necessary to steer the motive unit between guide plates which protrude from the forward end of the trailer to engage a single "V" shaped self-centreing wheel on the pivot with ramp attached to the motive unit. As this wheel rides up the ramp it lifts the trailer castors clear of the ground and the wheel then drops into an indentation in the ramp. Immediately this occurs two sturdy spring-loaded locking levers snap over the wheel spindle, thus locking it firmly in position. At the same instant a catch releases the trailer brakes. The pivot bearing on the coupling gear is a large 6in. diameter bronze bush mounted in a housing and attached to the trailer frame by two silico-manganese spring steel bars. These ensure a high degree of transverse rigidity while at the same time a slight amount of spring deflection enables the trailer platform to adjust itself on uneven ground. It also forms a flexible fore and aft coupling.

A four-cylinder 10 h.p. Treasury rating engine, designed to develop 32 b.h.p., drives the vehicle through a single plate clutch, and a three-speed synchromesh gear-box. The rear axle has a double-reduction spiral bevel drive giving a ratio of 38 to 1. The springing on the tractor is by a single transverse semi-elliptic spring in front and quarter elliptics at the rear. The trailer has semi-elliptic springs. A 19ft. turning circle is provided. The overall length of the vehicle is 18ft. and the unladen weight is 25¼ cwt. The loading surface of the trailer is 12ft. by 6ft., and the pay load is 30 cwt. to 50 cwt. The maximum drawbar pull on the spring-loaded tow hook is 2000 lb.

*(To be continued.)*

## Letters to the Editor.

*(We do not hold ourselves responsible for the opinions of our correspondents.)*

### A CALL TO ADVENTURE.

SIR,—Youth early learns that Age is its master in an argument. So I am conscious of my temerity in joining issue with the opinions put forward in a leader in your current issue. In excuse I can but say that I believe THE ENGINEER to be possessed of perennial youth, and that the leader was written at a passing moment of unusual pessimism. I had rather expected after listening to Colonel Davidson's address and Mr. Day's subsequent remarks that THE ENGINEER would have taken up the cudgels in defence of youth. But defence, which agrees with Colonel Davidson, and sets out to explain the reasons for the lack of the spirit of adventure, is not at all to my taste. For Youth has never been more adventurous than it is to-day.

Age has always questioned whether Youth has the true spirit of adventure, while, at the same time, illogically suppressing the ebullition should it make itself apparent. Invariably, too, Age's standard of measurement has been provided by that which was thought adventurous fifty years before. Fifty years ago the tide of emigration still flowed strongly; men married at the age of twenty with no prospects, and young men set up engineering firms with little more than faith in their own powers to support them. Hence, argues Age, to be adventurous now, Youth should do the same at the present day. Your leader exhibits the caution of Age in that while clearly believing adventure to be nearly dead, it leaves itself an avenue of escape should counter-arguments prove too strong. Adventurous Youth would have stated downright what it believed without thought for retreat.

Truly emigration has fallen away, and your leader puts clearly some of the reasons. But how many of those who sailed away to colonise the Dominions in the nineteenth century were really filled with the spirit of adventure? Is it adventurous to be given the choice either to emigrate or to starve?

Again, there can be no argument as to the age of marriage. It was frequently twenty then and it is about as frequently twenty-five now. But the conditions have altered. Just as, fifty years ago, a young man undertook the adventure of marriage as soon as he first began to

draw a salary or a wage, so to-day after a more lengthy education he does the same. He does not necessarily wait, as your leader suggests, until his prospects have grown secure.

As to the setting up by young men of engineering firms, the opinions of your leader seem based upon an airy nothingness, although the difficulties to be faced are well expressed. How many of the new firms, new works, new garages, and new businesses that are springing up to-day have young men directing them? There are no statistics upon which to base opinions. But to quote but one instance it should not be forgotten that it is not much more than twenty years since a youngster named Morris started a bicycle shop in Oxford. Youth has not gone to the dogs in the intervening years.

In other fields "Victorian" adventure is just as attractive to Youth as ever it was. If an expedition is proposed to the North or South Pole, to the summit of Mount Everest, to the sources of the Amazon, or to anywhere else on or perhaps off this globe, the difficulty of the organiser is not to gain recruits, but to make a choice from the hundreds who put their names forward.

So far this counter has been developed upon ground chosen by yourself—the standards of an age present-day Youth never knew. Adventure calls now upon a different ground. For it seems to me that the whole age is permeated by such a spirit of adventure that it may fitly bear comparison with the Renaissance of the fifteenth and sixteenth centuries. In the last hundred years, and especially the last fifty, the scientist and the engineer have wrought so great a change on the face of the earth that man's whole outlook must suffer a radical revision. Consequently, Youth has risen up to challenge the cherished beliefs and ideals of centuries. In every field there is unfettered adventurous, though often misguided, thought, turning wherever possible into rigorous action. Just as anything new or strange was certain to appeal to an Elizabethan, so to-day do we seek novelty, be it in ideas or things, and in the search the conventions and ideals of an earlier age are thrust aside. Nothing is so firmly founded that its truth cannot be challenged. The Newtonian creed in science is thrust down and scientists, despite their increasing knowledge, grow more humble. Classic economics shudders before the attacks of enthusiastic reformers. Political institutions fall and new ones grow Phœnix-like from the ashes. Governments, in frantic haste of legislation, try to keep pace with changing conditions. Sex is discussed in the open street. The existence of the Deity is questioned and argued over. New architectural forms emerge. Heretics are certain of a hearing, if not fame. The speed of travel rises higher and higher. A belief has but to be stated to be questioned and attacked. The world searches and seeks it knows not what, and travels it knows not whither.

To some the hurly-burly is a cause for pessimism, for it allows none of the security of less audacious days. So, too, it must have been in the clash of creeds and ideals 400 years ago. But the engineer has a great part to play in it. For him, as much as for anyone else, it is a duty to help steer mankind out of the whirlpool into calmer waters. In the discovery of the course to be followed lies a greater adventure than any mankind has tried for centuries. YOUTH.

November 2nd.

### THE L. AND N.E. STREAMLINED TRAIN.

SIR,—In your issue of October 11th, Mr. W. B. Thompson is hardly fair in his comparison between "Hardwick's" run over Shap and the L. and N.E. Newcastle-London record, both of which are at about 67 m.p.h. It must be remembered that the former was a special performance, not equalled on any other night, and it ought correctly to be compared with "Silver Link's" 76¼ miles out to Peterborough, which was done in 55 min., or at a much higher speed than 67 m.p.h.

Nevertheless, I am in agreement with Mr. W. B. Thompson in his contention that a great deal too much has been made of this run with a light train. Let us rather dwell on what our French and German friends can show us with really heavy trains behind the tender.

Finally, is not all this business about streamlining merely a kind of advertisement? A few nights ago I saw "Silver Link" bring the "Flying Scotsman" into King's Cross 3 min. late, and noted the immense frontal space below the chimney which she exposed to a head wind, and yet Mr. C. J. Allen says that "the mere increase from 60 to 70 m.p.h. increases head air resistance by more than one-half to stress the importance of streamlining equipment." JOHN P. PEARSON.

Edinburgh, November 1st.

## Oil-Engined Factory Locomotive.

THE 20 h.p. oil-engined locomotive illustrated herewith has recently been produced by the Hunslet Engine Company, Ltd., of Leeds, for use in works and factories which are in direct contact with a main line and which receive and dispatch main line wagons at intervals. In many such factories there is not sufficient work to keep a locomotive going full time, and horses, a gang of men, or a locomotive hired from the railway company for an hour or two are employed for the work when required. Apart from the inconvenience of these arrangements the cost is also considerable, and it is for such work that the locomotive illustrated has been specially produced.

The engine and its transmission are similar to those which the Hunslet Engine Company has built for some years for narrow-gauge work. The frame arrangement has been designed to make the unit suitable for buffing and coupling with main line rolling stock. The locomotive can be left standing for long periods, but can be started up within a couple of minutes. One man, it is stated, can start up and operate the locomotive, couple and uncouple the wagons, and carry out all the necessary marshalling and manœuvring operations. The locomotive can be started for a few minutes' work and then shut down again for some hours without inconvenience, and even if it is kept running continuously the cost, we are informed, is only about a shilling a day. The gear-change arrangement is based on the makers' main line practice, and embodies constant-mesh nickel-chrome, case-hardened gear wheels and a semi-automatic gear change. The locomotive is built with a two, three, or four-speed gear-box, depending upon individual requirements, and gives a maximum tractive effort of nearly 3000 lb. It is capable of hauling up to 150 tons on the level, and with a four-speed gear-box its speed may be as high as 14 m.p.h., although for all normal sidings a two-speed gear-box would probably be sufficient. Its weight is about 6¼ tons, and it carries sufficient fuel and water to operate for a full week. The engraving gives an idea of the type of work for which the locomotive is suited, although on low gear it can handle up to about half a dozen standard type wagons.

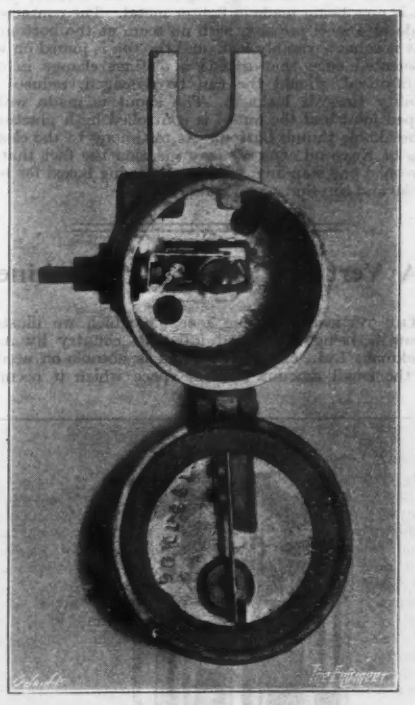
OIL-ENGINED FACTORY LOCOMOTIVE

## A Fault Locator for Overhead Lines.

THE Warren fault locator shown in the accompanying illustrations has been introduced by A. Reyrolle and Co., of Hebburn-on-Tyne, to enable operating engineers to find faults on overhead lines without undue delay and expense. The operation of the device depends upon the difference of potential set up by the passage of fault current to earth through the towers or poles in the immediate vicinity of a fault. This potential difference is utilised to send a current through a fuse consisting of a luminous indicator which has one terminal connected to the tower structure or the downcoming earth wire and the other to an auxiliary earth spike driven into the ground. In a circuit with an earth wire, the fault current flowing to earth is greatest at the towers or poles in the neighbourhood of the fault, and decreases rapidly with increasing distance from the fault. Care must therefore be taken to ensure that the current through the locators situated near the fault is sufficient to cause their operation, while the remaining locators are left intact. When the circuit is without an earth wire, however, only the locator mounted on the pole on which the fault occurs is affected. After a fault the locators are readily examined by connecting a test battery across each in turn, when failure to indicate shows that the fault has occurred at or very close to the tower or pole under test. The locator is contained in a small cast iron box fitted with a waterproof hinged cover, having a spring catch and provided with a key to prevent unauthorised interference. An adaptor plate is fitted to the box to enable it to be mounted directly on steel towers, as shown in one of the accompanying illustrations.

MOUNTING OF LOCATOR ON TOWER

The device is suitable for use on the entire range of overhead lines. Where supplies are given over single-circuit lines, the periods during which consumers are inconvenienced by being cut off while the faults are located and repaired, are said to have been considerably shortened.



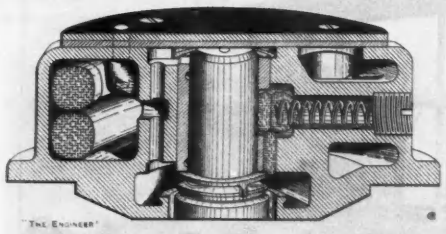
FAULT LOCATOR

## A New Sleeve Bearing for Small Motors.

WITH a view to increasing the reliability of their "minor" motors, Crompton Parkinson and Co., Ltd., of Bush House, W.C.2, have introduced a new sleeve bearing claimed to simplify lubrication and to avoid trouble when these motors are used for driving domestic machines entrusted to the care of unskilled people. In this new and patented "Marathon" bearing the housing is designed on the lines of an unspillable inkwell. It is, in consequence, completely leakproof, irrespective of the position it occupies. Motors may be dispatched with the bearings filled with oil and ready for immediate service. The wells hold enough oil for one or two years' service under normal conditions. A separate wick supplies oil (in addition to that escaping at the ends) to the thrust collars. Axial movement of the rotor arising from external end thrust is cushioned without shock by strong spring washers at each end. The thrust washer in rubbing contact with the bearing is keyed to the shaft, thus preventing relative rotation between the thrust washer and packing shims, and thereby eliminating a source of wear and resultant end play. A free flow of oil is ensured by duplex woven

wool wicks of ample cross section and by employing diamond bored bearing bushes which have a glass smooth surface from the outset, thus avoiding the tendency for slackness to occur after the running-in process. All Crompton "minor" motors within the range of $\frac{1}{30}$ to $1\frac{1}{2}$ h.p. are now fitted with these bearings.

Another feature of interest is the brush lifting and short-circuiting gear fitted to the firm's repulsion induction machines. On all motors with the exception of two-pole motors four brushes are provided. The lifting gear is positive in action and the brushes cannot remain in an intermediate position while the machine is running. The



SLEEVE BEARING FOR SMALL MOTORS

brush rocker is a heavy die casting spigoted on the motor end shield and clamped firmly in position.

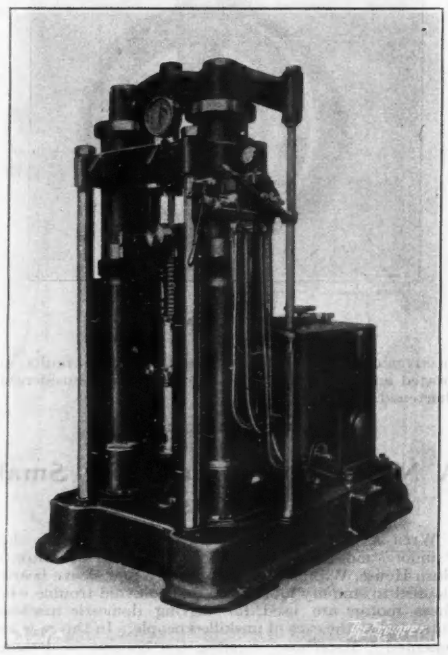
The short-circuiting gear consists of a single phosphor-bronze disc backed by a strong compression spring, these being mounted on a sliding bush which carries the brush lifting ring and operated through tension rods by centrifugal governor gear.

## A New Oil Can.

THE locks and the oil feeders made by Joseph Kaye and Sons, Ltd., of Leeds, are so well known to engineers that they hardly need be mentioned, but we feel justified in attracting attention to the new design of oil feeder which has recently been brought out. It is of the same general form as the familiar type, one of which we have had in service without any regrets for some thirty years, but is now being made in lighter metal. The container is made of a steel pressing with no seam at the bottom, so that it cannot possibly leak, and the top is joined on with a serrated edge that avoids a distinct change in continuity and, should the can be damaged, reduces the liability towards leakage. The spout is made with a lapped joint and the outlet is controlled by a practically unbreakable thumb button. As testimony to the cleanliness of Kaye oil cans we may mention the fact that we have had one standing, full, on a drawing board for some weeks and can find no oil stain.

## A Vertical Broaching Machine.

THE vertical broaching machine which we illustrate below is being introduced into this country by A. C. Wickman, Ltd., of Coventry, and is notable on account of the small amount of floor space which it occupies.



VERTICAL BROACHING MACHINE

It has a maximum stroke of 47in. and a peak pulling capacity of about 10 tons.

The broaching operation is performed upwards—that is to say, the work-piece is placed beneath the crosshead, which can be seen mounted on four vertical columns, and the broach is pulled upwards through it by the top yoke connecting the two hydraulic rams. These rams are of comparatively large diameter and work at a reasonable pressure, so that the machine operates quietly and there is no high frequency vibration. The pressure oil for operating the rams is supplied by an "Enor" pump, which allows a stepless variation of the working speed, and is driven through reduction gearing by a 15 h.p. electric motor. The gearing is so devised that it will accommodate the varying height of different designs of motors. The same motor drives a pump for the coolant and operates the control gear.

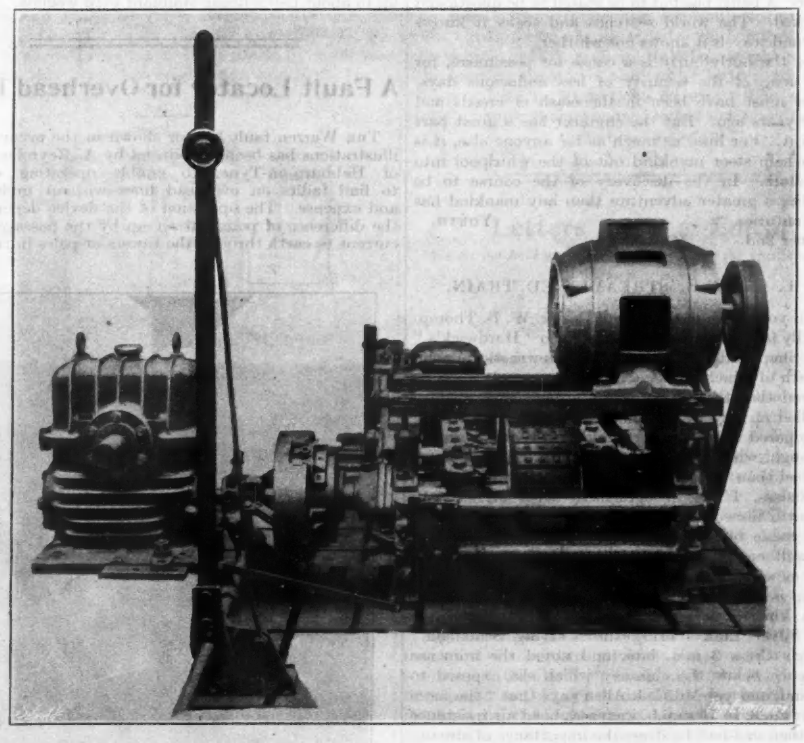
In operation the work-piece is dropped over the top end of the broach, and the control lever is pulled over. Then, automatically, the broach is lifted by an auxiliary cylinder until it is caught in a chuck in the pulling yoke. The auxiliary ram retires and the broaching stroke starts. When the hole has been finished, the yoke and rams fall of their own weight, but are cushioned by an oil dashpot at the bottom of the stroke. The broach also drops and the jar when it stops shakes off all chips and swarf. The finished article, being released, rolls down a chute into any convenient receptacle. Gauges are provided for showing the oil pressures, and there is also a safety valve which lifts if the pulling force exceeds the safe limit for the broach in use. This valve can, of course, be set appropriately.

## A Variable-Speed Machine Drive.

A VARIABLE-SPEED drive which has some rather unusual characteristics, but is nevertheless built up of standard units, made by Crofts (Engineers), Ltd., of Bradford, is illustrated in the accompanying engraving. It is driven by a constant-speed electric motor, running at 720 r.p.m., which can be seen mounted on the framing on the right, and drives the final shaft, on the left, at any speed between 20 and 80 r.p.m.

The first step in the drive is made by means of a pair of V ropes, and gives a reduction in speed of two to one. There is then a standard Croft variable-speed gear, of the expanding pulley type, giving a further reduction ratio of four to one. The movement of the cheeks of the pulleys of this gear for the purpose of altering the ratio is effected by a small reversible electric motor, which can be seen in the background, and is controlled by push buttons in a convenient position. A tachometer is provided so that the progress of the speed variation may be observed and regulated according to requirements.

The drive then passes through the rim friction clutch in the foreground, controlled by the upstanding hand lever, to a Croft worm gear with a nine to one reduction ratio. The case of this gear, as will be seen, is ribbed to assist cooling the lubricant. The clutch naturally enables the machine to be started and stopped without interfering with the running of the motor, but there is a master switch in the circuit of the motor. With the drive illustrated, it was essential that the machine should always restart at the minimum speed, so that the clutch lever on disengagement controls the reversible motor, thus ensuring that the variable-speed shaft returns to its lowest speed, and there is no possibility of the machine being restarted at the speed reached before the drive was de-clutched. The machine can also be arranged for electrical interlocking between the master switch and the clutch lever, so that the machine cannot be brought to rest before being de-clutched when the speed of the variable-speed shaft is reduced to the minimum

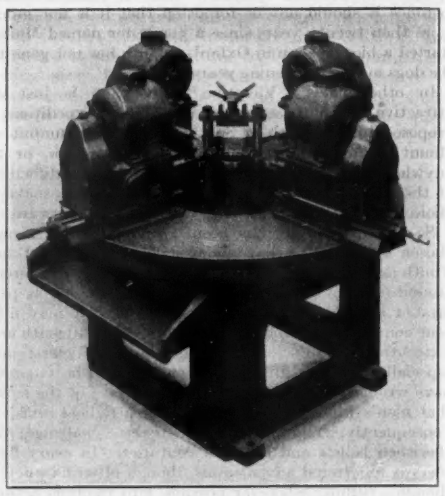


VARIABLE SPEED MACHINE DRIVE

## A Quadruplex Drilling Machine.

THE machine which we illustrate herewith might be described as typical of a four-handed game of cards. There are four "heads" arranged round a circular table, each of which is independent in its actions, but all of which operate on a central position. The arrangement is made possible by the adoption of an independent electric drive for each head, and the machine is made by Kitchen and Wade, Ltd., of Arundel-street, Halifax, Yorks.

As will be readily appreciated, the work-piece to be operated upon is arranged at the centre of the table, and is held in a quick-acting jig. In the case illustrated, four $\frac{11}{16}$in. holes have to be drilled and reamed at the four quarters of a circle, so four heads are provided, but it is possible to extend the equipment to five heads. Each head is driven by a high speed 1 h.p. electric motor, and a noiseless reduction gear drives the drilling spindle



QUADRUPLEX DRILLING MACHINE

below. Each head has its own slide base, with a screw adjustment for setting, tool changes, &c., and is fed up to its work by a cam which gives a cycle of operation, including a quick advance to the work, the correct feed for the machining operation, a quick return to the "out" position, and a dwell for unloading and reloading the work-piece. If it is necessary, a dead stop can be arranged in the place of the divett, when more elaborate pieces have to be put in place, but generally the timing can be so arranged that the machine runs continuously and no time is wasted.

The cams for operating the feeds are positive in action, and do not involve the use of springs. They are driven through pick-off change-speed gears, and run in oil. The spindles run in ball bearings and have hardened nickel-steel driving gears. The swarf made in machining is led away by the chute seen in the engraving, so that it may be taken away by a conveyor or any other convenient means.

SINCE the formation of the Coal Mines Reorganisation Commission amalgamations involving 228 pits have been effected, according to the Minister of Mines, when answering a question in the House of Commons. He was unable to state, however, how many of these had been due directly or indirectly to the activities of the Commission. The cost of the Commission from the date of its inauguration to September 30th, 1935, amounted to £123,150. This figure includes £32,583 in respect of fees and expenses paid to professional and technical agents, which, in certain circumstances, are recoverable.

# The Germs and Development of Some Mechanical Inventions.*

By C. F. DENDY MARSHALL, M.A., M.I. Loco. E.

In the days before photographic processes were available for reproduction, and even later, owing to the established fashion, it was the practice for illustrations given in histories dealing with technical subjects to be redrawn instead of being reproduced direct from the original sources, a process which lent itself to all kinds of unauthorised embellishments, omissions, and even distortion. It is thought that an assemblage of reproductions of the earliest illustrations that exist of some of the more important inventions—in most cases those furnished by the inventors themselves—will be found to be of interest and to have some value as a contribution to technical history.

As the address deals principally with the early history of engines and pumps, there are only three men prior to the seventeenth century who call for mention, namely, Archimedes, Ctesibius, and Heron of Alexandria.

The result of recent research is that we know much less

FIG. 1

about the dates of Ctesibius and Heron than our fathers thought they did. It used to be said that Heron flourished about 130 B.C. and was a pupil of Ctesibius. It now seems probable that the latter was the "Ctesibius mechanicus" mentioned by Athenæus as having lived in the third century B.C.

From a study of Heron's works it has been deduced that he probably lived at a considerably later period than hitherto supposed. The most recent opinion is that he cannot be placed for certain earlier than somewhere between the first century B.C. and the third A.D.

It is by no means clear, moreover, how far the inventions described by Heron are his own, or to what extent he is merely giving an account of those of his predecessors.

As the earliest MSS. of his works are posthumous to the extent of more than a thousand years, it is impossible to provide the original drawings in his case. The eleventh proposition from "Spiritalia" is the first known application of heat to produce the motion of fluids—Fig. 1.

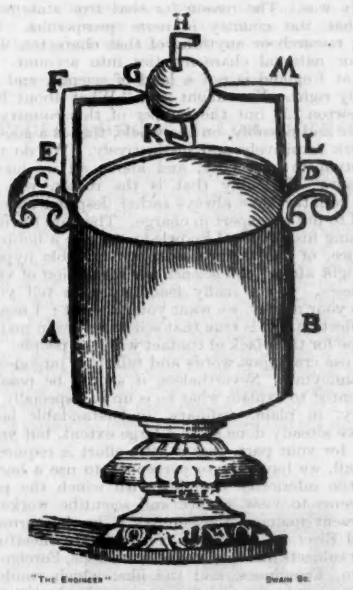



FIG. 2

The altar and its pedestal are air-tight. When a fire is lighted on the former, the air in the latter expands and forces wine or other liquid up through the tubes in the figures, which then appear to be pouring a libation.

The thirty-seventh proposition shows a device for opening temple doors by the agency of heat. When the fire is lighted, the air within the altar expands and presses on water in a spherical vessel, causing it to overflow into a bucket, which gradually acquires sufficient weight to open the doors by turning the vertical spindles on which they are hung. The thirty-eighth is simpler still, being a pure hot air engine. Air from the altar descends into a bag made from the skin of an animal, which shortens as it becomes distended, and pulls directly on the cords. The hinges must have been kept well greased!

But the fiftieth proposition is the gem of the collection, being the first steam engine (Fig. 2), commonly called the æolipyle. It may be remarked that no fire is shown. But the very first words of the text are: "Il riscaldato vaso di acqua ripieno A B" (The heated vessel filled with water). Hence it must have been intended to be stood on an altar or some other source of heat.

## Pumps.

Before the end of the sixteenth century, considerable progress had been made in the design of water pumps. Agricola, in his "De Re Metallica," first published in 1556, shows a three-stage lift. In another illustration he includes iron crank shafts with the cranks at 180 deg.

A still more remarkable development is given by Aleotti,

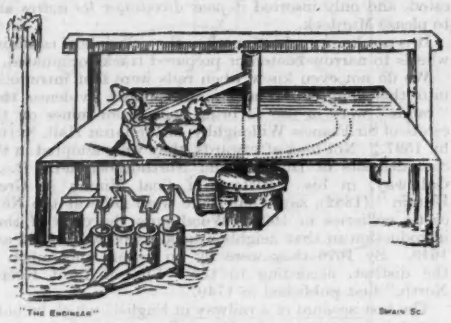



FIG. 3

who translated Heron's "Spiritalia," in 1589, in an appendix to the book, which shows a four-cylinder pump with cranks at right angles (Fig. 3). It looks just like a motor car engine upside down.

At the beginning of the seventeenth century, another proposal for a steam engine appeared, in a book by Giovambattista della Porta, published in Latin at Naples in 1601. A translation into Italian came out, also at Naples, in 1606. His apparatus is illustrated in Fig. 4, which was not given in the Latin edition of 1601. Instead of using air as the displacing fluid, as shown by Heron in the temple-door engines, he employed steam generated in a separate vessel D, which passed into a closed chamber B and forced out water from it. The furnace looks like a castle, but the scale of the apparatus can be judged from the fact that the capacity of the vessel D is given as one or two ounces of water only.

We now come to Solomon de Caus, who has been claimed by Frenchmen to be the inventor of the steam engine—see, for example, Arago's "Eloge of James Watt," where it is said that de Caus was the first to see that water heated to a high temperature might be available for raising great bodies of that fluid to any conceivable height, and that

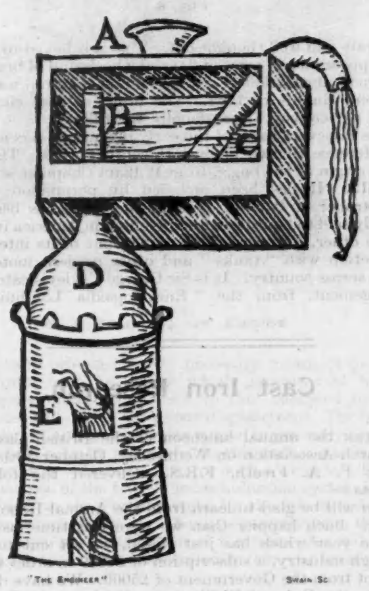



FIG. 4

his apparatus will always make a noble figure in the history of the steam engine. The invention on which so great a reputation rests is shown in Fig. 5. He had been describing means by which water can be raised above its level, the first being by a syphon, the second by a piece of cloth overhanging the side of a vessel. He then goes on (translation): "The third means of raising it is by the aid of fire, for which there can be various machines. I will give the demonstration of one. Let there be a ball of copper marked A, well soldered all round, with a tap marked D by which one puts in the water, also a tube B C, which will be soldered in the top of the ball, the end C approaching close to the bottom without touching it. After having filled the said ball by the tap, then close tightly and put it on the fire; the heat playing on the ball will make all the water rise by the tube B C."

That is the whole of Monsieur de Caus's contribution to the invention of the steam engine. Obviously he attached little importance to it or he would have had more to say on the subject in a folio volume of about 180 pages. All he did was to demonstrate the force of steam under pressure, which had often been done before.

In 1629 Giovanni Branca, in a book published at Rome, described the first steam turbine—well known—which he suggested for the purposes of working stamps for pounding drugs. This is the first machine worked by steam power, designed to do a particular operation, since Heron's temple-door openers.

During the next few years three English patents were granted, which might possibly have had steam engines of some kind in view, but there are no specifications enrolled, nor are there any records of their ever having been applied in practice.

## The "Century of Invention."

We now come to one of the most interesting, but at the same time baffling, characters in the branch of history with which we are dealing, namely, Edward Somerset, Second Marquis of Worcester. A perusal of Dircks's Life of him leaves one full of sympathy for his misfortunes and admiration of his fertile imagination, but, it must be confessed, an opinion that he was rather what schoolboys call a "gasser." At the same time the language he employs must not be judged by modern standards. It is evident that the vagueness was intentional, in order to baffle would-be imitators.

Worcester's little book, "The Century of Inventions," was published in 1663, but had been in manuscript as early as 1655. Dircks gives a list of eleven reprints, three of which are not satisfactorily authenticated, and probably never existed. Six are exhibited to-night. The original was described as being "extremely scarce," as early as 1778. Probably many of the unsold copies perished in the Fire of London. Another possible reason for its rarity is the story told by Desaguliers that Savery bought up all the copies he could find "in Paternoster Row and elsewhere, and burn'd 'em in the presence of the gentleman [very likely Henry Beighton], his friend, who told me this."

The sixty-eighth clause, describing what is called in the index a "Fire Water Work" and elsewhere a "water-

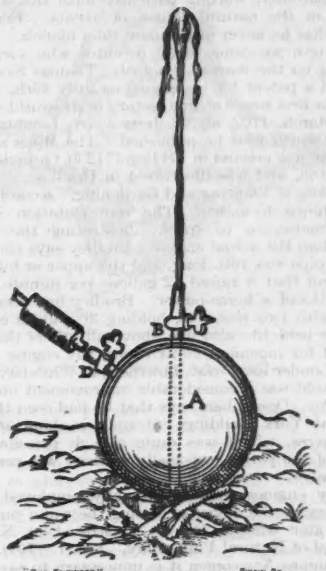



FIG. 5

commanding engine," has been often quoted. The copy of the first edition shown to-night has a separately paged supplement bound up with it, beginning "An exact and true Definition of the most Stupendious Water-commanding Engine," &c. This is absent from all the other editions, except the last one, by Partington, 1825. Unfortunately, it adds very little to our knowledge of the engine, but it sets out that no external help or force is required "but what intrinsecally is afforded from its own operation," thereby excluding anything of the nature of a water wheel. No one can deny that Worcester had conceived the idea of a powerful double-chambered steam apparatus which would force water up to a great height; not suck it up, as he knew, possibly from experiment, that there was a limit to the height attainable by that process. As far as it is possible to visualise his real meaning, the engine seems to be on the same principle as the one afterwards introduced by Savery, except that it did not employ suction.

The next question is whether his plans were ever put into practice. There is evidence of the existence of an engine at Vauxhall. Two books, one by the Frenchman Sorbière, writing in 1663, and the other, an account of the travels of Cosmo de Medici, in 1669, state that there was a hydraulic machine invented by the Marquis of Worcester at Vauxhall, which raised water 40ft. in an 8in. pipe. Sorbière says "by the strength of one man," and the other account "by the power of one man only." These expressions have often been taken to mean that the machine was merely a manually worked pump. There are, however, some weighty reasons why this opinion is unlikely to be correct. Firstly, it is improbable that two independent travellers would have taken the trouble to go and see a pump worked by one man and write accounts of it afterwards. Secondly, the Medici book says it was considered of greater service to the public than one near Somerset House, which was worked by two horses. It is true that Sorbière said he preferred the horse machine, but, taking the two accounts together, one would infer that their powers were more or less of the same order.

When reading these descriptions, we must try to put ourselves in the position of the writers, remembering that they were probably seeing, for the first time in their lives, an almost incredible and quite incomprehensible machine, worked by power generated within itself, and operated by the mere turning of cocks; with no outward and visible water wheel nor windmill nor horse plodding round. Surely in the circumstances it was not unnatural for them to use the expression "by the power of one man," mean-

* Excerpts from the Presidential Address to the Newcomen Society for the Study of the History of Engineering and Technology. October 16th.

ing simply that only one man was required to operate it. Worcester tells us exactly what he did, thus: "A man that tends the work is but to turn two cocks, that one Vessel of water being consumed, another begins to force and refill with cold water, and so successively, the fire being tended and kept constant, which the self-same Person may likewise abundantly perform in the interim between the necessity of turning the said Cocks." No doubt he became very hot in the process. Altogether, the evidence that the Vauxhall engine was worked by steam, it is submitted, is good and sufficient.

We must not pass over Sir Samuel Morland, who experimented very considerably in hydrostatics and hydraulics, constructing the first "steam tables," and was "Master of Mechanicks" to Charles II. In 1661 he obtained a patent for a machine to raise water by a vacuum produced by exploding gunpowder, which would have been one of the earliest internal combustion engines. He invented an improved plunger pump, which, however, was worked by manual power. A manuscript is in existence, dated 1683, in which he describes, vaguely as usual, a method of raising water by steam.

Our attention is next claimed by Denis Papin, of whom Arago says, "It is Papin whom France will have to thank for the honourable place which she can claim for herself in the history of the steam engine," which is perhaps a little inconsistent, after all he had said about de Caus just before. But here Arago was on firmer ground, as Papin was the first to propose the production of a vacuum under a piston by condensing steam, and also invented the first practical and satisfactory safety valve.

From about 1690 onwards Papin was attempting the design of "machines to raise water to great heights by the use of fire." Here, in point of fact, he was just ahead of Savery; but in one respect his ideas were much more advanced, as they embodied a cylinder and piston. In another way they were hopelessly unpractical, as he proposed to cool the cylinder by removing it from the fire, and, apparently, waiting patiently until the steam condensed, in the natural course of events. Even Arago admits that he never made more than models.

At length we come to an inventor who succeeded in "getting on the market," namely, Thomas Savery. He obtained a patent for his engine on July 25th, 1698, and set up the first steam engine factory in the world some time before March, 1702, at Salisbury-court, London. In the last-mentioned year he published "The Miner's Friend." An engine was erected in 1711 or 1712 at Campden House, Kensington, and was illustrated in Bradley's "New Improvements of Planting and Gardening," second edition,† 1718 (shown to-night). The representation is merely diagrammatic, so to speak, illustrating the principle, rather than the actual engine. Bradley says the lower or sucking pipe was 16ft. long, and the upper or forcing pipe 42ft.; and that it raised 52 gallons per minute, which is nine-tenths of a horse-power. Bradley had seen another engine with two receivers, holding 36 gallons each—this one only held 13—also one above all others that he had heard of for ingenious contrivance, the engine belonging to "— Louder Esq." (*i.e.*, Lowther), of Whitehaven, which he was told was a considerable improvement on Savery's invention. Desaguliers says that he had seen the Savery engine at York Buildings (Strand) working at 8 to 10 atmospheres, which was quite a high pressure for the boilers of the period, especially as there was probably no safety valve.

Savery engines were occasionally employed to drive machinery by the device of letting the water pumped fall on a water wheel. One is illustrated in Nicholson's "Journal of Natural Philosophy," Vol. I (1797).

Of Thomas Newcomen it is unnecessary to say much to members of this Society. To Papin's piston and cylinder he added the beam, thereby solving the weight difficulty by balance, and supplied valve gear to enable the engine to function automatically. His first engine was erected near Dudley Castle in 1712.

Those of us who attended the meeting at Sheffield in the summer of 1931 will remember that we were privileged to see a Newcomen engine working, at the Fitzwilliam Collieries, Elsecar, near Barnsley.

### Automobiles.

Turning to the subject of automobiles, no doubt the idea of using steam for locomotion occurred to many people as soon as it became known that considerable power could be obtained from it. Actually, the first thing to move itself was a model made by Father Verbiest, a Jesuit missionary at Pekin, about the year 1684. It is described in a rare book, entitled "Astronomia Europæa," by P. P. Ferdinand Verbiest, S.J., published at Dillingen, Bavaria, in 1687 (Chapter XXIV, Pneumatica). The description, which is in Latin, is to the effect that about three years before, while investigating the power of the aeolipyle, he made a little chariot, 2ft. long, on four wheels, in the middle of which he placed a vessel full of live coals, and above that, an aeolipyle. On the axle of the front wheels there was a bronze ring with teeth, driven by gear wheels from one with four wings, on which the jet from the aeolipyle impinged. He was, of course, using the word to mean a little boiler with a spout to it. By means of a tiller connected with the rear axle, he made the carriage run in a circle. He also suggested other applications, including the propelling of a boat.

It is stated in some books on the steam engine that Newton proposed a carriage propelled by a jet of steam issuing from the back. He never did anything so absurd. An explanation of the way in which the error arose will be found in Mr. Rhys Jenkin's book "Motor Cars" (1902), page 42.

The second model of which records exist was one made by Papin about 1698, which had a cylinder and piston. He proposed it for military purposes.

The credit for the first full-sized machine rests, of course, with Nicholas Cugnot, who appears to have built two, one in 1769 and one in 1770; the latter being still in existence, in Paris.

Another full-sized machine was made by Thomas Charles Auguste Dallery, at Amiens in 1780. He was an interesting character. Particulars of his life are given in a rare little work "Origine de l'Helice propulso-directeur et de la chaudière tubulaire, exposée par Chopin-Dallery," Paris, 1855. He was a maker of organs and other musical instruments, of considerable repute in his day, later in life turning to jewellery and making rings containing minute watches, &c. He took out a French patent, dated March 29th, 1803, which covered a boat and a vehicle, driven by a two-cylinder engine, with a water-tube boiler. The boat was to be driven by two screws, fore and aft, the one at the bows being pivoted for steering. The car was also boat-shaped, and was balanced on a single pair of wheels in the centre, with small safety wheels near the ends.

Murdock's model was exhibited in 1784 or 1786. The actual date of its construction is not known for certain. Symington made a more ambitious one in 1786.

This brief sketch may be closed by mentioning that Watt included claims for a steam carriage in his steam engine patent of 1784. There is no drawing. He proposed a change-speed gear for hills. But he was not really interested, and only inserted it *pour décourager les autres* and to please Murdock.

It is not known where or when the principle of confining wheels to narrow beaten or prepared tracks originated.

We do not even know when rails were first introduced into this country. There is undoubted evidence that "rails" were in use to bring coals from mines on the estate of Sir Francis Willoughby, of Wollaton Hall, Notts., by 1597.‡ Not long afterwards, they were adopted in the coal districts of Durham and Northumberland. R. L. Galloway, in his "History of Coal Mining in Great Britain" (1882), says that there were none at the Newcastle collieries in 1600. Wood puts the date of their introduction in that neighbourhood as between 1602 and 1649. By 1676 they were by no means uncommon in the district, according to the "Life of Lord Keeper North," first published in 1740.

The first account of a railway in English, which includes any detail, was given by Desaguliers, in his first volume (1734). It was written by Charles Labelye. The railway had been laid down by Ralph Allen, of Bath, in 1730, to bring stone from his quarries in the hills to the Avon. He used edge rails, with very deep flanges on the wheels, which were of cast iron. The axle, which is shown, was square at one end and round at the other, allowing a differential rotation on curves. The brake gear was

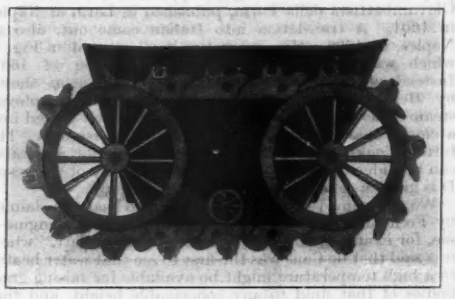


FIG. 6

elaborate and well thought out. This is believed to be the first appearance in print of flanged wheels and of brakes.

A good illustration of a wagon on an edge rail was used by John Buddle in 1764. The brake at that time was called a "convoy," occasionally a "tiller."

This review of some of the early inventions is concluded by reference to two nineteenth-century ones. The first is the origin of the bogie, from William Chapman's patent of 1812. It has been included by permission of the Comptroller of Patents, because the bogie has been frequently said to have been first invented in America in 1832.

The other, Fig. 6, is given on account of its interest in connection with "tanks" and other modern motors for going across country. It is Sir George Cayley's caterpillar arrangement, from the "Encyclopædia Londiniensis," 1827.

† The first edition, which appeared the previous year, did not contain the plate of the engine. It was reproduced in Newcomen Society "Transactions," III, Plate XX.

‡ THE ENGINEER, September 29th, 1911.

## Cast Iron Research.

AFTER the annual luncheon of the British Cast Iron Research Association on Wednesday, October 30th, 1935, Major F. A. Freeth, F.R.S., delivered the following address:—

You will be glad to learn from the Annual Report that we are much happier than we were this time last year. In the year which has just closed, we set out to raise, through industry, a subscription of £7000 in order to earn a grant from the Government of £5000. We have done it, but, as the Duke of Wellington said about the Battle of Waterloo, "it was a close run thing." For subscriptions that we raise over £7000, the Government have promised us pound for pound. We have set ourselves out to get an income of £20,000 per annum. I think you will agree that when you consider the turnover of our industry, which is in the neighbourhood of thirty to forty million pounds a year, this sum can in no way be considered excessive.

You will also notice in the statement of accounts that we have had an income of £1300, derived from sources other than grant-earning subscriptions. It is with the greatest satisfaction that we can tell you that a good deal of this has been earned in payment for the design of our balanced blast cupola, and applied to meet the actual cost incurred.

### Our Research Position.

We are now branching out in research in directions which we are certain you will agree are useful and promising. For example, we are working on the melting quality of various cokes, and the addition of natural clay to sands. This latter point is of the greatest importance in view of the increased tendency towards continuous production and mechanisation in our foundries. As regards the metal itself, we have appointed a special man to deal with the shrinkage and contraction. Some of you must be already familiar with him and his work.

Our process of graphite refining has also attracted a great deal of interest. We have covered this by patent, so there is no harm in my giving you a rough outline of the process. We add to molten pig or cast iron a small quantity of titanium. The metal is then subjected to a treatment by an oxidising gas for a determined period, and in this way it is possible to convert high carbon pig iron, cast iron, or even scrap iron into an iron having the graphite in an extremely finely divided form, as finely divided as, in fact, it is possible to obtain graphite in cast iron. We do not know the theory of this yet, but the fact remains that we have done it.

We have also discovered how to reverse the above process; that is to say, we can make a cast iron, which originally contained fine graphite, contain a coarser graphite, which is useful under certain circumstances.

This kind of research, as you will easily realise, will necessarily proceed slowly, and I am sure you will bear with us when we tell you that we are eventually sure of success, and we wish to walk before we can run.

The Iron and Steel Industry Research Council is helping us in our work to produce fine structure in ingot moulds and to ascertain the effect on the life of the castings.

We are also studying the effect of other elements upon cast iron, such as copper, molybdenum, and aluminium. When I was in Brussels at the Iron and Steel Congress last year, there was a paper given upon the properties of an alloy containing 15 per cent. of aluminium, which showed the most remarkable resistance to oxidation.

We are also working in cordial co-operation with the National Physical Laboratory, particularly on subjects such as creep strength and the resistance of cast iron under combined flexural and torsional stresses. The first results of this latter investigation were presented on Friday last, November 1st, to the Institution of Mechanical Engineers.

### Study Course.

Two years ago we organised a three-day study course at our headquarters, and we were surprised and rather embarrassed by the fact that over 150 members turned up. We are going to do a similar thing on November 6th, 7th, and 8th next. I think you will agree with me that the large number of members who responded is a direct and most practical tribute to the Director of Research and his staff. Nobody would turn up for a course of this character unless he was pretty certain he was going to get something out of it.

Now I am going to say a few words about the Director of Research and the Research Laboratory itself. In Mr. Pearce we have the Director, who, apart from his genius for research and scientific initiative, combines that necessary chameleon-like quality of juggling with finance and the thousand-and-one household cares which beset the modern Director of Research. There is no harm in saying a thing twice. The first time I went round your research department, I was most favourably struck by the economic and efficient manner in which you had got the most for your money. Anybody can waste money; it is difficult to spend money effectively, and you are in the fortunate position of having done so.

### Science and Research.

Speaking about ten days ago, when opening a new laboratory under the ægis of the electrical industry, the Duke of Kent remarked that a few years ago there seemed to be a great deal of interest in research, and he was under the impression that the interest was not as great as it formerly was. The reason for that true statement was this—that the country is more prosperous. In discussing research or anything of that character, we must take our national characteristics into account. Liebig said that England is not a land of science, and he was perfectly right. You might say, "What about Faraday and Newton?" but the temper of this country is not scientific and possibly, on the whole, that is a good thing. We work intuitively and instinctively. We do not like intellectualism or theory, and above all we loathe the doctrinaire. Probably that is the reason why people in this country have always rather despised experts and refused to put an expert in charge. They are terrified of a man using his technical knowledge to ride a hobby horse.

Science, of course, proceeds by verifiable hypotheses. You might almost call science the realisation of verifiable hypotheses. I am really leading up to tell you that besides your money, we want your interest; I nearly said your affection. It is true that scientists are in many ways to blame for their lack of contact with the people. We are apt to use crack-jaw words and talk in a jargon which is most annoying. Nevertheless, it should be possible for the scientist to explain what he is up to, especially in your industry, in plain, ordinary, understandable language. We have already done so to a large extent, but you must realise, for your part, that a little effort is required, and, above all, we have got to overcome, to use a hackneyed term, the inferiority complex with which the practical man seems to view science and scientific workers. At the present moment the country is in the turmoil of a General Election. All sorts of people are cheerfully discussing subjects like the League of Nations, Foreign Policy, Pacifism, Economics, and the like, which would make Minerva's head ache and give her wise fowl what poultry-keepers would term "the pip." All this is done with a cheerfulness that beggars description. Now the matters with which we are dealing are far more simple and at the same time there is a certain fixity about them which rather precludes the talking of nonsense. I do implore all of you who possibly can to take an active interest in what we are doing. The effect on all, from your Director of Research down to the mechanic in your Research Department, is far greater than you can imagine in mere terms of money. For your interest, you will learn something yourself and you will automatically encourage your staff to further efforts.

I said a moment or two ago that we are working on the addition of other metals to cast iron, and it is more than likely that we are achieving valuable results. When I first spoke to you before you made me President, some three or four years ago, I was urging upon the Association the necessity for buying an electric induction furnace. At

the time, trade was bad, but as you know, trade is now very much better, and still we are without our induction furnace. There is another matter. The other day, I was quite casually in an establishment of a very famous firm of opticians when I saw a projecting microscope which had rather a familiar appearance to me. I found to my horror that it was the identical microscope that was lent to our Association for the exhibition held in conjunction with the Department of Scientific and Industrial Research at Olympia. Gentlemen, that microscope costs about £250, and it seems to me that somehow or other that money should be raised. The induction furnace is a much bigger matter, but I again commend it to you, for if we had one we could quadruple the speed of our work.

### The Department of Scientific and Industrial Research.

I should like, once again, to emphasise the cordiality and reasonableness with which the Department has met us on all points. The Government Departments, which in the long run are fed by the Treasury, probably the most hard-boiled community in Great Britain, are naturally a little hard-boiled themselves. Nevertheless, the Department has treated us with the greatest generosity and consideration. It is difficult under any circumstances to organise research, but when it is organised by the Government it becomes still more difficult. The essential nature of research lies in individual thinking, and all great and original thinking is essentially individualistic, and here is where the paradox comes.

We have to work by committees. You will see in the Annual Report the large numbers who serve well and untiringly on some of our committees, and you might say, "What on earth do you mean by pleading for individualism to a co-operative association, which is necessarily run by committees?" The answer is that it is a paradox which always makes any discussion of research apparently futile, unless we have the mutual goodwill of those who work with us. It is true that research is individualistic, but if you have a committee and the individuals of that committee take some trouble really to make the work with which they are concerned part of their own individuality, then you will get a committee at its best. If, on the other hand, your committee attends meetings in a perfunctory manner, you will get a committee at its worst, that is at the lowest depths of intellectual degradation.

### The Foundry School.

We have started, as you know, a foundry school, with the object of training young men to be better founders than they otherwise would have been. Personally, I loathe the word training. To me it is slightly reminiscent of sea lions and performing fleas. We have deliberately set our faces against that doctrinaire system which obtains in some institutions and countries. We have said to ourselves, "We will take a young man who has a natural flair for founding and we will not exactly train him, but we will put material before him to bring out the aptitude which will be part of him, and make a more useful founder." You will remember in Flexner's book the large college in the United States which was run by a graduate of Domestic Economy and Dietetics. It was run at a loss, and a considerable loss. Financial pressure compelled the authorities to go more closely into the matter, and they appointed a cook and turned a substantial loss into a substantial gain. We have to avoid like the plague a man saying "I am a trained founder." If he does, you shoot him! The object of our school, as I have said before, is to help people to help themselves. The best training in the world is gained by sitting at the feet of a teacher; the second best is what we are able to teach ourselves.

To recapitulate, gentlemen, we want a little more of your money, a little more special money for the purposes mentioned, but, above all, we want your interest.

## The Eight-Cylinder 2-Ton Fordson.

In The Engineer of October 25th last mention was made of the new 2-ton commercial vehicle produced by the Ford Motor Company, Ltd. The complete vehicle, shown in Fig. 1, is a most interesting piece of designing and has a performance which justifies every departure from standard practice. Perhaps the most unusual part of this vehicle is the engine, which is an eight-cylinder unit of 30 h.p. R.A.C. rating. In Fig. 2 we reproduce the horse-power, torque, and fuel consumption curves. As will be seen, high revolutions are attained. Although the cylinders are set at 90 deg., they actually form a single casting, which includes the upper half of the crank case. For this vehicle detachable cast iron cylinder heads are used, which provide for a compression ratio of 5·3 to 1. This figure is somewhat lower than that used on the similar aluminium head engine of the passenger vehicle and enables lower-grade fuel to be used. High-tungsten-chrome alloy steel valve seats are fitted. They are produced as rings, 0·002in. larger than the diameter of the recesses into which they fit. They are then cooled in a liquid oxygen bath to a temperature of —190 deg. Cent. and fitted. A special type of fully floating big end bearing is used, lined with a copper-lead metal developed by the Ford Company. It will stand considerably greater impact than the usual white bearing metal, and the company claims that bearing failure has been practically eliminated. A forced lubrication system is provided for

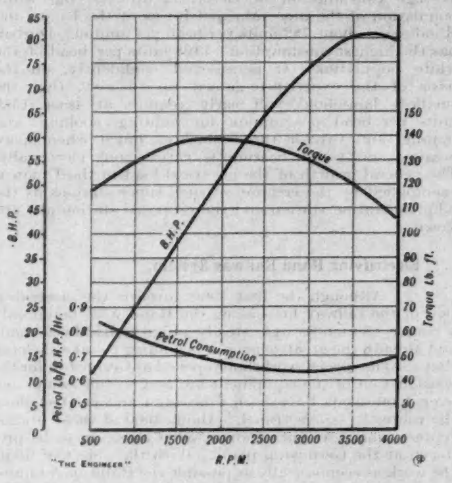



Fig. 2—Characteristic Engine Performance Curves

main, big end, and cam shaft bearings. Oil flung off the big ends has been found adequate to lubricate the cylinder walls. The water cooling system employs pump circulation, and the cylinder jackets are carried right down to the crank case, where they have a cooling effect on the lubricating oil. In addition, the crank case has a special ventilating system. A breather fitted with a filter projects from the cylinder block in the line of draught from the fan. The latter drives air down through it and around the crank case, where it cools the oil and, taking all fumes with it, passes out at the front end of the crank case. The

Fig. 3—Removal of Engine

cooling system provides a very necessary means of overcoming fumes from an engine which generates 81 h.p. within a space almost equivalent to that occupied by a four-cylinder unit of half the piston displacement. The fuel consumption of an eight-cylinder engine is generally high, but, as will be seen by the curve, in this case it has been kept to within a very fair figure for such a vehicle. The inherent balance of the four-cylinder induction system has been retained on the Fordson eight by the use of a dual carburetter which feeds each bank separately and thus retains the even gas distribution of the four. As will be seen in Fig. 3, the engine can be readily removed from the frame, a special jig being employed. The exhaust manifolds are removed and the jig is bolted in their place on the block. The engine can then be unbolted and rolled forward and out of the vehicle. No difficulty arises in the removal of the radiator. This system of engine removal has the advantage that a spare engine can be used as a replacement unit with a fleet of vehicles and no vehicle need be idle. The mounting of the engine unit itself is on rubber blocks, two in front of the engine and one at the rear of the gear-box, which gives good insulation from vibration.

The transmission includes a clutch designed to minimise driving fatigue in traffic. It is a single-plate unit, the plate diameter being 11in. The friction area is 123·7 square inches. The three clutch release fingers are mounted on needle roller bearings. Each of these levers is weighted so that centrifugal force acting on the weights increases the pressure on the friction surfaces, so that the limit of adhesion is always more than that required for the torque produced by the engine. The spring pressure is only 1215 lb., which is sufficient only to provide adhesion when the engine is "ticking over." At higher engine speeds

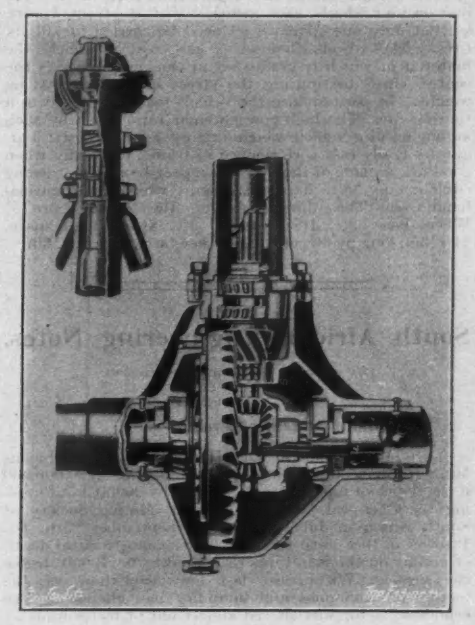


Fig. 4—Final Drive Assembly

the centrifugal effect provides the rest of the necessary pressure. The resultant clutch action from the driver's point of view is that of an ordinary touring car, no greater force being required for clutch manipulation. We had the opportunity to observe a test in which the vehicle was allowed to run down a gradient estimated at 1 in 5 with reverse engaged and then stopped and moved backward up the hill by the clutch. Perfectly sweet "take-up" occurred though the torque reaction caused the engine to shift momentarily on its rubber bearers. The actual pressure produced at 3700 r.p.m. is just over 2400 lb. The gear-box used on this model gave ratios of 5·14, 8·67, 15·9, and 32·9 to 1, reverse being 40·22. The performance provided by the use of four speeds was fully equal to any traffic conditions likely to arise. On third gear 30 m.p.h. is attainable and on second any main road gradient can be

Fig. 5—Removal of Axle Shaft

surmounted with full load. Ball or roller bearings are fitted to all points in the transmission and final drive. The latter incorporates an additional bearing to the normal two. It is fitted behind the bevel pinion, thus overcoming any tendency for the latter to "whip." A further safeguard to the back axle gearing, which also ensures that proper mesh is maintained, is the provision of a plug in the axle casing, which, in the event of the crown wheel being displaced by torque reaction, meets the crown wheel and stops further movement, thus protecting the axle bearings from excessive end thrust and the final drive teeth from damage. Both these points are illustrated in Fig. 4, which shows the two ends of the transmission tube. The provision of this form of drive is yet a further refinement on the Fordson and carries out the intention of the designers of providing a vehicle which will stand up to

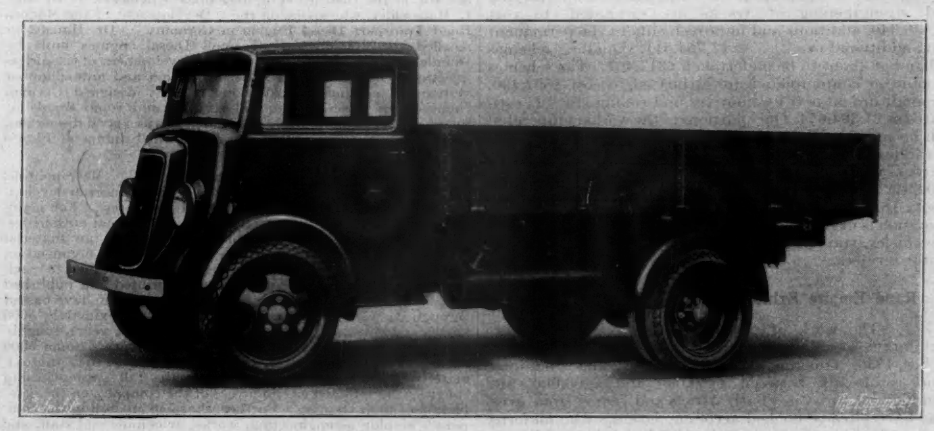


Fig. 1—Eight-Cylinder 2-Ton Fordson Lorry

hard use or even abuse in service. The frame used is 7in. deep in the mid-section with flanges 2¾in. wide, pressed from ¼in. thick metal. Five cross members are fitted. The first carries the load of the front ends of the springs and also the steering gear-box. The second carries the rear end of the engine. The third carries the front end of the torque tube and is further braced by a longitudinal joining it to the second cross member. The fourth is an inverted trough section, gusseted to the frame and placed close to the front attachments of the rear springs. The fifth is placed between the rear ends of the springs. The suspension is by semi-elliptics, all round, the leaves of the rear springs being graduated in thickness. The ease with which repairs may be carried out is well shown in Fig. 5. Here an axle shaft is being removed without jacking up the vehicle. The operation is further simplified by combining in the hub caps a shaft puller and cover plate. The cover plate is fitted with two bolts, which, when tightened, purchase against the wheels and exert a pull on the shaft. Full floating wheel mounting allows the latter to be withdrawn without reference to the weight of the vehicle which is carried by the axle casing. The whole construction of the chassis is similar in design. Dual tires are fitted in rear on four wheels, each identical with the front wheels, so that only one spare wheel need be carried for all six tires. The wheels themselves are steel pressings, the material in which is graduated in thickness towards the centre, thus distributing the stress evenly and saving weight. In performance the vehicle may be likened to a touring car. The high power-weight ratio given by such an engine in a vehicle weighing only 3 tons 19 cwt. 3 qr. gives a really fast performance in traffic, especially when good use is made of the four-speed gear-box. The turning circle is only 36ft. diameter, a figure which gives unusual handiness. The dimensions of the vehicle are:—Wheel base, 9ft. 10in.; track, 4ft. 8½in.; load space, 11ft. 3in. long by 6ft. 6in. wide; height of sides, 1ft. 6in.

## South African Engineering Notes.

*(By our South African Correspondent.)*

CAPE TOWN, October 15th.

### Gold Mining at Lower Levels.

ACCORDING to Dr. Hans Pirow, Government Mining Engineer, South Africa could gain £280,000,000 if the depth of mining was increased by 2000ft. Addressing the Chemical, Metallurgical and Mining Society of South Africa in Johannesburg on September 25th, Dr. Pirow said that until recently the ultimate vertical depth of mining on the Rand was estimated to be 7000ft. below the surface. Within the last few years, however, the factors of economics and humidity had changed. The economic factor was altered almost out of recognition by the abandonment of the gold standard. Thus the average pay limit, which formerly was in the vicinity of 4·3 dwt. per ton, now is approximately 2·9 dwt. per ton, with gold at £7 per ounce. Recent research indicated that temperature and humidity can also be dealt with more adequately. Hence, though very optimistically, it appeared to him to be within the range of possibility that a vertical depth of 10,000ft. might be accepted before long as the limiting depth for Rand mining. Referring to the economic value of an increase of 2500ft. in depth, Dr. Pirow said that at a dip of approximately 25 deg. this increase would bring about 200,000,000 tons into the ore reserves in the existing mines. Assuming an average yield of four penny-weights, with gold at £7 an ounce, this tonnage would give a revenue of £280,000,000. Of this amount nearly £200,000,000 would be distributed in South Africa. It was therefore self-evident that any success they may have met with in reducing temperature and humidity at a great depth will automatically be translated into a golden harvest for the industry in South Africa.

### Kalahari Survey.

Irrigation possibilities in the northern part of the Kalahari Desert are to be explored by the Minister of Agriculture and the Union Director of Irrigation when they fly to Ngamiland during this month (October). Colonel Denys Reitz and Mr. Lewis will be accompanied by pilots and a mechanic. There will be three machines and the party will be away for about six days. During this period they will make a thorough reconnaissance of the whole of the Northern Kalahari with a view to the possible irrigation of the country. They will concentrate their attention on Lake Ngami and the Okavango marshes and the rivers that feed them, and they will have an opportunity of judging for themselves the practicability of the much-discussed Schwartz scheme. The country to be explored is in Bechuanaland and under the control of the High Commissioner. The visit of the Minister and the Director of Irrigation is in conformity with the policy of co-operation between the Union and the Imperial authorities on irrigation matters. It is a matter that vitally affects the Union as a whole. The Protectorate authorities have shown great interest in the proposal to irrigate the Northern Kalahari and a preliminary survey of the country and its irrigation possibilities was recently completed by a Union engineer seconded to the Commissioner's office. It is possible that as the result of this visit a joint scheme by the Union and the Imperial Governments may be instituted.

### First Union Petrol on Sale.

The first step in the actual production, for the first time in the Union of South Africa, of petrol to be refined and distributed by a South African company was taken at Boksburg on Wednesday, September 18th, when crude petroleum produced from the torbanite mined by the company at their torbanite mine at Ermelo was discharged into the storage tanks of the S.A. Torbanite Mining and Refining Company. The crude petroleum was carried by a special tanker train from the company's bulk settling installation at Durban, and until a sufficiently large stock of crude oil has been accumulated at the company's refining plant special trains will be run at passenger speeds to Boksburg. South African refined petrol, according to the latest official information, will be on sale early in December through pumps painted in the Union colours and erected where considered warranted.

### Electrical Consumption Growing.

There has been a 36 per cent. increase in the consumption of electric current in South Africa in the last five years. Most municipalities are looking forward to at least doubling their present outputs before saturation point is reached. The big scope for future development is indicated by the fact that the average consumption of electricity by the big white population of the nine principal towns of the Union and Rhodesia is about 782 units per head per annum. Durban has the highest consumption—1408 units per head of the white population. It is asserted confidently, on the basis of the experience gained up to now, that the smallest household will early require at least 1500 units per head per annum for lighting, cooking, and ironing, and two or three times as much when space heating and water heating is carried out electrically. The general growth of the electrical load in the Union is exemplified by the erection of such super stations as the Klip generating station and the proposed station at Cape Town.

### Electrifying Rand Railway System.

Although the first steps towards the electrification of the railway lines along the Rand were taken only a couple of months ago, steady progress has been made and already the great scheme is beginning to take skeleton shape. The special workshops opened at Germiston for the construction of the equipment are now in full swing, and over 1500 masts have been fabricated and erected along the routes to be electrified. About 4000 of these towers, representing a weight of about 5000 tons, are to be produced at the Germiston plant. With the object of doing the work as economically as possible the Railway Administration has been using old rails as raw material. The experience gained on the Harrismith and Natal sections has shown that there is no loss of efficiency. By the end of the year it is possible that most, if not all, of the masts will have been fashioned and erected. A number of the old coaches will also be adapted to the new system. These coaches will be 60ft. long and 9ft. 1in. wide, which compares favourably with the dimensions usual on the South African Railways. The electrification scheme is not expected to be completed for two or two and a-half years, but much depends on circumstances as to whether the time will be reduced or increased. The routes to be electrified are Johannesburg to Germiston and Apex, Apex to Welgedacht, Apex to Springs, Langlaagte through Nancefield to Pimville and from Langlaagte to Orlando. Up to the present 259 miles of main lines in the Union have been electrified and work is proceeding on the electrification of a further 123 miles. In the Cape suburban area 42 miles have been electrified, and the mileage to be electrified in the Witwatersrand suburban area is 76½ miles. The total mileage of electrified lines in the Union amounts to 301 and work is proceeding on the electrification of a further 199½ miles.

### Railways Order Coaches and Buses.

Reductions in the road transport rates have led to a great increase in traffic, and the Railway Road Motor Service Department has ordered 100 new motor buses. In Natal buses are now conveying material to the gold mines at Nkandhla, a distance of 73 miles from the railhead. The chassis of the 100 vehicles ordered will arrive at Durban shortly. The bodies will be constructed departmentally. Orders for seventy-two electric motor coaches to be used on the Witwatersrand when the electrification of the system is completed have been placed by the Railway Administration. The orders involve a total expenditure of more than £475,000. The contract for the electric equipment has been secured by the General Electric Company of America. The whole of the bodywork will be carried out by the Birmingham Carriage and Wagon Works.

### Expenditure on Union Railways.

In the estimate of expenditure on Capital and Betterment Works for the year ending March 31st, 1936, approved by Parliament during its last session, provision is made for many works of considerable importance. The total sum voted, which will form a charge to Loan and Betterment Funds, is £4,666,143, of which £3,512,318 is allocated to new works on existing lines, £545,150 to harbours, and £113,659 to rolling stock. In addition, it is estimated that £5,631,421 will be financed during the year from the Renewal Fund on various works and rolling stock. The bridge building and improvement programme which the Administration has in hand is estimated to cost £1,438,598. Works in hand or contemplated for relaying and strengthening of tracks are estimated to cost £3,846,740, additions and improvements to the permanent way, additional track, &c., £1,764,511, signalling schemes in hand or about to be undertaken £317,407. The schemes in hand or contemplated are estimated to cost £592,130. Expenditure on new locomotives and rolling stock is estimated at £4,394,674. Only portions of the works enumerated will be spent in the current financial year. For instance, of the last item only £2,191,287 will be expended in the current year, made up as follows:—New locomotives, £602,372; new coaching stock, £658,024; new wagon stock, £817,232; additions and improvements, £113,659. Provision is made to the extent of £194,200 for the purchase of vehicles, trailers, and repair shops equipment for road motor services.

### Rand Empire Exhibition.

The work of preparing for the Rand Empire Exhibition at Johannesburg, which is to open in September, 1936, is making excellent progress. The guarantee fund is already between £150,000 and £200,000, and hundreds of firms in South Africa and scores from overseas have already booked accommodation. The majority are availing themselves of the buildings erected by the Executive, but large concerns, such as the gold mines and the South African Iron and Steel Industrial Corporation, are erecting their own buildings.

### Port Extensions at Durban.

It is learned that the Nijhoff recommendations dealing with the provision of additional deep-water berths at Durban and the deepening of certain existing berths are receiving the immediate attention of the Administration, and that a start is to be made soon with an extension of the wharf at present terminating opposite "1" shed for 1000ft., and also with an extension of the wharves at Island View oil sites.

### Dunswart Iron and Steel Works.

The Dunswart Iron and Steel Company at Benoni, Transvaal, has just set in operation the first electric furnace to be constructed in South Africa. The only portions of this new 12-ton furnace not manufactured on the spot were the plates, which are of imported British steel. Twenty-three years ago Dunswart steel was turned out by the first mills erected in this country. To-day the works is producing 8000 tons of steel and manufacturing many other lines in addition. The works now employs 170 Europeans and 460 natives. Though Dunswart specialises on steel, the ironfoundry can produce any class of work.

## PERSONAL AND BUSINESS ANNOUNCEMENTS.

A. P. BEER & SON have removed their offices to 19, Ludgate-hill, London, E.C.4.

MR. W. STANLEY MOSS informs us that he has removed his offices to Coronation House, 4, Lloyd's-avenue, London, E.C.3.

## LAUNCHES AND TRIAL TRIPS.

JOHN KING, tug; built by Charles Hill and Sons, Ltd., Bristol; to the order of C. J. King and Sons, Ltd., Bristol. Diesel engines, constructed by Petters, Ltd., Yeovil. Launch, Monday, October 21st.

RUTLAND, steamship; built by the Caledon Shipbuilding and Engineering Co., Ltd., to the order of Messrs. James Currie and Co., Leith; dimensions, 260ft. by 40ft. by 18ft. 6in.; to carry passengers and cargo. Engines, triple-expansion; constructed by Barclay, Curle and Co., Ltd.; launch, October 24th.

A. ANDREEW, motor vessel; built by the Netherland Shipbuilding Company, Ltd.; to the order of the Russian Mercantile Marine, Moscow; dimensions, 92 m. by 14·90 m., to carry timber. Diesel engines, single-acting, two-cycle type; constructed by Maschinenfabriek Gebr Stork and Co., N.V., Hengelo. Launch, October 26th.

WALERII MESHLAUK, motor vessel; built by the Netherland Shipbuilding Company, Ltd.; to the order of the Russian Mercantile Marine, Moscow; dimensions, 92 m. by 14·90 m.; to carry timber. Diesel engine, single-acting, two-cycle type; constructed by Maschinenfabriek Gebr. Stork and Co., N.V., Hengelo. Launch, October 26th.

DUNEDIN STAR, cargo motor vessel; built by Cammell, Laird and Co., Ltd.; to the order of the Blue Star Line, Ltd., London; dimensions, 522ft. 5in. by 70ft. by 43ft. 4½in.; to carry cargo. Diesel engines, two Sulzer single-acting, two-stroke cycle, 720 mm. diameter and a stroke of 1250 mm. Launch, October 29th

## CATALOGUES.

A. C. WICKMAN, Ltd., Coventry.—"Correct Use and Maintenance of 'Wimet' Tipped Tools."

CROFTS (ENGINEERS), Ltd., Thornbury, Bradford.—Catalogue V.G. 835 on variable speed gears.

PETTERS, Ltd., Yeovil.—Publication No. 2333 on "Atomic" marine oil engines in sizes from 4 to 300 b.h.p.

GREENWOOD AND BATLEY, Ltd., Leeds.—An illustrated specification of "Greenbat" petrol trucks and tractors.

METALLISATION, Ltd., Pear Tree-lane, Dudley, Worcs.—A new booklet on corrosion elimination by metal spraying.

B.E.N. PATENTS, Ltd., Gorst-road, Park Royal, London, N.W.10.—A new brochure on spray painting equipment.

BUCK AND HICKMAN, Ltd., 2, Whitechapel-road, E.1.—The 1935 edition of the company's general catalogue, which contains over eleven hundred pages of lists and illustrations of the various small tools and supplies for all mechanical trades, together with many useful formulæ and tables.

ENGINEERS' GERMAN CIRCLE.—The second lecture arranged by the Engineers' German Circle was given on Monday, November 4th, at the Institution of Mechanical Engineers, by Dr.-Ing. L. Hausfelder, who spoke on the "Development of the Modern Road Transport Diesel Engine in Germany." Dr. Hausfelder recalled the first high-speed small Diesel engines built by Daimler-Benz, and traced the modern development of the airless injection principle and the direct injection and ante-chamber systems of combustion. Various recently designed German engines were described and illustrated, and some trends of future development were outlined. There was a good discussion, and after the meeting there was an informal dinner at Eliot's club, Charing Cross-road.

A DIRECTORY OF M-V APPRENTICES.—The Metropolitan-Vickers Electrical Company, Ltd., has been a pioneer in developing and carrying out the training of its *personnel*. For many years, by the closest co-operation with educational authorities, technical centres, and the Empire's universities, raw material in the form of *personnel* has been passed into the organisation through specially selected training courses suitable to each particular type. The company has just printed and published a register of the ex-apprentices and ex-trainees who have passed through its works. This register contains approximately 5000 names and covers a period of about thirty-three years, roughly coincident with that of the company's existence. Some 5000 names occur in the register, and we are informed that approximately 90 per cent. of those taking the full apprenticeship courses were retained as employees of the company on the completion of their training. Further, that 550 are still in the company's employ as engineering, works, or commercial staff, and that an additional 650 still hold employment as artisans in the company's works.

# Markets, Notes and News.

**The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.**

### The International Steel Position.

Since the beginning of October a distinct change for the better has occurred in the position of the British and Continental steel industries. To begin with, the export markets, particularly in the East and the Far East, bought heavily as a safeguard against possible international trouble arising from the Abyssinian War and an interference with their supplies. Whilst the British steel makers benefited to a considerable extent from this movement, a still larger share of the orders went to the Continental works. In this country the export demand, in addition to the vigorous home demand, has brought about stringent conditions, which, in turn, have helped the Continental industry by making it necessary to increase the imports of foreign steel. One consequence of this is that the Belgian works, which were particularly badly off for orders at the half-year, are now assured of an outlet for their production until January. It is reported that the orders taken by the Belgian Cartel's selling organisation in October totalled 180,000 tons, more than has been sold in any other month this year. The sanctions which have been imposed against Italy, however, have created some discontent amongst the Belgian steel makers, who complain that the orders for billets which they formerly received from Italy are now being placed with German makers. The steel works in Germany have a large tonnage of orders upon their books, but it is difficult to say how much represents direct business as against barter transactions. The extent to which the German works resort to the latter method of trading continues to arouse dissatisfaction amongst other members of the Steel Cartel, but for the time being they seem unable to take any preventive steps. The French market is agitated by the efforts to establish comptoirs, and it is believed that the Government is about to take a hand in persuading recalcitrant steel makers to moderate their demands for increases in their quotas, which, hitherto, have stood in the way of an agreement. The British steel makers have pressed for the formation of a thin sheet comptoir, and this is proving difficult owing to the number of works producing this material on the Continent and the variety of their products. The fact also that in many cases the works have their own extras list is an obstacle to the formation of an organisation.

### The Pig Iron Market.

Nervousness on the part of consumers regarding the position which is developing in this market appears to be growing. The producing concerns are not only carrying a heavy tonnage of orders, but many of them are disinclined to add to their forward commitments. This attitude has brought consumers into the market with the intention of safeguarding their forward position against a threatened stringency and the possibility of an increase in prices. For some time there have been indications that the producers would like to raise their selling prices, but the general understanding between the iron and steel producers and the Government that quotations would not be raised if Protection were granted the industry has stood in the way. There is no doubt, however, that the stringency in nearly all the pig iron producing districts is sufficient to enable the establishment of a higher range of prices, and that consumers would grumble, but pay. It is not surprising, therefore, that the Midland ironmasters last week raised their prices 4s. to 5s. per ton. This may have some effect in checking the insistent demand from buyers, who in some cases have been anxious to book for delivery until the end of next year, and have succeeded in buying so far forward as September. The quotation for Derbyshire No. 3 foundry was advanced 4s. to 75s., and Northamptonshire to 72s. 6d. from 67s 6d., whilst the price of forge qualities, the demand for which is by no means active, remains at the old margin of 5s. below the No. 3 quotations. On the North-East Coast the situation remains tight, but the producers are said to have denied rumours that an advance in prices of Cleveland brands is contemplated. Whether the movement in the price of Midland irons will affect their attitude remains to be seen. The makers in this district seem disinclined to take on new forward business, and the volume of prompt sales is restricted by the small proportion of the output left over when contract commitments have been satisfied. In Scotland the tone of the market remains firm, and it is possible that an attempt will be made to increase prices this month from the present official minimum of 70s. for No. 3 foundry, f.o.t. furnaces. The light castings foundries are well employed, but are said to have covered the greater part of their needs up till March next year. Lately the demand for hematite has become stronger and the producers are getting in much the same position as are the makers of foundry iron. All the output of hematite is passing into consumption, and there have been good bookings up till the end of next June. The outlook as regards prices, however, is somewhat uncertain, as there is a possibility that the price of ore will be advanced.

### Scotland and the North.

The orders upon the books of the Scottish steel works are sufficient to ensure a steady output for some months to come, and the recent contracts which have been placed with the Clyde shipbuilders will bring a considerable tonnage of new business in plates and sections. The orders for ships were placed when the demand from the shipyards had considerably decreased in volume, and the prospect of an increase in specifications for this class of steel is welcomed by the makers. The constructional engineers in Scotland have been busy for some months and their requirements are likely to be maintained at a high level. The demand for joists and sections forms a good proportion of the total output of Scottish steel and the tendency is for the production to increase. The re-rollers, however, might in some cases be better off for work, although their position as compared with pre-duty days leaves little cause for complaint. Orders for small steel bars have not been coming to hand lately with the regularity noticeable a month or two ago, and some of the re-rollers complain of the competition of English firms outside the Association. The quota of Continental merchant bars offered for delivery in November has been sold out without apparently having made much impression upon the market. A noticeable improvement has taken place during recent weeks in the position of the boilermakers, many of whom have good orders in hand and count upon obtaining attractive contracts in the near future. As a result more business is being transacted in boiler plates than has been the case for a long period. The demand for semis is as urgent in Scotland as in other districts, and lately the price of sheet bars has been increased, most makers now asking £5 10s. The volume of business in billets seems to be expanding rather than declining, although most of the producers in Scotland have sufficient work in hand to keep them busy for weeks to come. In the Lancashire district it is becoming increasingly difficult to obtain prompt supplies of billets, but this applies less to the high-carbon qualities than to the cheap untested steel descriptions. Most of the makers of sections in Lancashire have lengthened their delivery times, a fair number of contracts having been placed lately. It seems evident that large quantities will be required during the remainder of the year by the constructional engineers. On the North-West Coast the steel works are busy and have good orders in hand both for structural steel and for hoops.

### The Midlands and South Wales.

A persistent pressure on the part of consumers to accelerate deliveries and to place long-term contracts has been the principal feature of the steel markets in the Midlands. The impression seems to be growing that an advance in the prices of various classes of steel in most general demand may come at short notice. In several departments there is a definite scarcity of materials and consumers complain of the difficulties they experience in obtaining delivery against their contracts. This is principally noticeable in the semi-finished steel department, and although the Federation is understood to have purchased a large quantity of billets for re-sale to its members, this has not so far had much influence upon the position. The minimum price remains at £5 10s. for soft untested billets in 100-ton lots; but not only is it difficult to place orders, but if business is accepted it is generally at about £6. Some Continental material has been released for the Midland district, but not nearly enough to meet the requirements of users. Continental billets have been offered at the old price of £5 9s. for 2in. and £5 8s. for 2¼in. The constructional engineers have shown anxiety to place forward contracts, but they were met with a certain amount of reluctance on the part of manufacturers and comparatively few long-distance commitments were accepted. In the meantime most of the constructional engineering concerns are complaining of delays in deliveries and a good deal of dissatisfaction has been expressed on this score. Business in steel bars has been on an active scale of late and the release of a good tonnage of Continental material relieved some of the most pressing demand, although only a limited tonnage was distributed in the Midlands. Practically all the re-rollers are well employed and are not inclined to book forward except as a favour. The recent advance in prices has been maintained and reinforcing bars are now impossible to obtain at less than £8 d/d Midlands from either associated or non-associated works, whilst for other qualities the unassociated concerns ask £8 2s. 6d. The demand for black sheets has improved of late and the works are assured of good working conditions for some time to come. In South Wales activity at the steel works is growing and the tone of the market has been improved by the announcement that the Ebbw Vale Iron and Steel Works may be reopened by Richard Thomas and Co., Ltd. The tin-plate works are still out of the market for export business for delivery before January.

### Current Business.

The London, Midland and Scottish Railway Company's programme for 1936 includes the expenditure of about £2,232,000 and will provide for 687 new passenger coaches and 9235 freight wagons. Orders have been allocated as follows:—Fifty 30-ton bogie bolster trucks and one hundred 20-ton tube wagons (Hurst, Nelson and Co., Ltd., Motherwell), two hundred 20-ton tube wagons (Charles Roberts and Co., Ltd., Wakefield), three hundred and fifty 20-ton hopper wagons (Metropolitan Cammell Carriage, Wagon and Finance Company, Ltd., Smethwick), two hundred 20-ton hopper wagons (Birmingham Railway Carriage and Wagon Company, Ltd., Birmingham), one hundred 20-ton hopper wagons (Gloucester Railway Carriage and Wagon Co., Ltd., Gloucester). An order has been placed with Cammell Laird and Co., Ltd., Birkenhead, for new machinery for H.M.S. "Renown." S. P. Austin and Son, Ltd., Sunderland, have received orders for two colliers, each of 4600 tons deadweight. Lobnitz and Co., Ltd., of Renfrew, have obtained a contract from the South African Railways and Harbours Administration for two tugs. An order for a fishery patrol vessel for the Lancashire and Western Sea Fishery Joint Committee has been placed with A. and J. Inglis, Ltd., Glasgow. Harland and Wolff, Ltd., have obtained an order for three twin-screw motor vessels of 2500 tons each from the Burns and Laird Lines, Ltd. The Great Western Railway Company's programme for next year includes the reconstruction of about fifty bridges. Head, Wrightson and Co., Ltd., of Thornaby-on-Tees, are to extend their drop forging plant for the production of parts for motor cars. The Department of Overseas Trade announces that the following contracts are open for tender:—Cairo, Ministry of Public Works (Mechanical and Electrical Department): supply of workshop machinery comprising belt planing machines, precision lathe, &c. (Egypt, December 7th); Argentine, State Oilfields: 2000 metal cabinets for housing one complete super-gas outfit (two cylinders and one regulator) each, seamless and welded iron and steel piping of diameters ranging from ⅜in. to 10in. (Buenos Aires, November 28th).

### Copper and Tin.

Comparatively little business has been transacted during the past week in the market for electrolytic copper. Consumers evidently intend to wait until the course of international events can be better estimated, and in the meantime are working on the stocks purchased during the recent buying movement. On the other hand, producers are comfortably situated and are likely to have to draw upon stocks to fulfil their contract requirements. The full effect of the restriction of output is now making itself felt, and in some cases producers who sold electrolytic freely on the London standard market have taken advantage of the recent decline in values in that department to buy back their metal. Inquiries for copper continue to be received from Italy, but little business has matured, as, although the export of copper to Italy has not been prohibited, the sanctions make it necessary for all transactions to be on a cash basis. The financial situation of Italian buyers makes it almost impossible for more than minor dealings to be arranged. An easy tone has prevailed in the standard market, but the sagging tendency has been rather due to the absence of buyers than to the volume of realisation. At the present level of prices the metal is regarded as being cheap, and an improvement in the international situation would probably lead to an advance in values. . . . The position in the tin market has not altered much, although the prospect of more tin arriving in the latter part of November had naturally had a depressing influence upon prices. The scarcity of prompt metal, however, continues acute, and is indicated by a further reduction in the stocks in this country. The backwardation remains at over £12, and it is not surprising that dealers are inclined to mark time. Tin is one of the metals of which the export to Italy is prohibited after November 18th.

### The Lead Market.

Lead prices have been well maintained and on the steadier tone which developed this week consumers began again to take an active interest in the market. Although an increase in supplies may be anticipated at the beginning of December, when Mexican lead will begin to arrive on this market, the revival in demand from home consumers and the heavy requirements of Continental users are likely to take care of all the metal coming forward. In fact, it is suggested that stringent conditions may develop, as the stocks in official warehouses in this country have been steadily reduced of late and from 17,136 tons at the end of June now amount to only 7847 tons. Interest has been taken in the possibility of supplies of Mexican lead, which in the ordinary course of events would come to this country, being diverted to Italy, as Mexico is not affected by the Sanctions. The position in the United States has improved considerably during the past month or two and the figures show the stocks at the end of September as 224,732 tons, compared with 227,583 tons at the end of August. The world production in September was 120,326 tons, compared with 126,971 tons in August, the total production for the first nine months of the year being 1,138,267 tons.

### Average Non-ferrous Metal Prices.

The prices of all the principal non-ferrous metals dealt in on the London Metal Exchange showed an appreciable improvement in October over those ruling in the previous month. There were considerable fluctuations in values during the month, but upward movements were sufficiently sustained to make an increase in the average. For cash copper the average in October improved by £1 3s. 9d., whilst for three months it was £1 3s. better than in September. The electrolytic quotation improved by £1 14s. 6d. and for wire bars by £1 15s. 10d., the best selected price being £1 12s. better. In tin also a substantial rise is shown. The average price for cash metal in October was £3 5s. 7d. better than in the previous month, whilst for three months tin it was £4 16s. 9d. up. The rather sensational movement in the lead market last month is reflected in a rise in the average price for shipment during the current month of £1 19s., whilst the average for shipment the third following month was £1 17s. 11d. higher, the mean showing an improvement of £1 18s. 5d. Spelter showed an increase of £1 0s. 6d. on the average quotation for shipment during the current month, the rise for shipment the third following month being £1 1s. 2d. better, and the mean £1 0s. 10d. higher than in September. The following are the London Metal Exchange official average quotations for October:—

| | | | | |
|---|---|---|---|---|
| Standard Copper | Cash (mean) | £35 | 5 | 2 13/24 |
| | 3 Months (mean) | £35 | 12 | 5 1/24 |
| | Settlement | £35 | 5 | 2 13/24 |
| Electrolytic Copper (mean) | | £39 | 10 | 4 5/24 |
| Electrolytic Wire Bars | | £40 | 6 | 6 5/24 |
| Best Selected Copper (mean) | | £39 | 1 | 4 5/24 |
| Standard Tin | Cash (mean) | £227 | 8 | 10 23/24 |
| | 3 Months (mean) | £217 | 9 | 1 1/24 |
| | Settlement | £227 | 6 | 11 1/24 |
| Lead | For shipment the current month | £18 | 4 | 2 5/24 |
| | For shipment the third following month | £18 | 4 | 2 5/24 |
| | Mean | £18 | 4 | 2 5/24 |
| | Settlement | £18 | 4 | 2 5/24 |
| Spelter | For shipment the current month | £16 | 8 | 9 1/24 |
| | For shipment the third following month | £16 | 13 | 5 17/24 |
| | Mean | £16 | 11 | 1 19/24 |
| | Settlement | £16 | 9 | 1 19/24 |

# Current Prices for Metals and Fuels.

Makers' official home trade prices per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.; plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

## PIG IRON.

| | Home. | Export. |
|---|---|---|
| | (*D/d Teesside Area*) | |
| N.E. Coast— | £ s. d. | £ s. d. |
| Hematite Mixed Nos. | 3 10 6 | 3 2 0 |
| No. 1 | 3 11 0 | 3 3 6 |
| Cleveland— | (*D/d Teesside Area*) | |
| No. 1 | 3 10 0 | 3 4 0 |
| No. 3 G.M.B. | 3 7 6 | 3 1 6 |
| No. 4 Forge | 3 6 6 | 3 0 6 |
| Basic (*Less 5/– rebate*) | 3 10 0 | — |
| Midlands— | | |
| Staffs.— | (*Delivered to Black Country Station*) | |
| North Staffs. Foundry | 3 15 0 | — |
| „ „ Forge | 3 10 0 | — |
| Basic (*Less 5/– rebate*) | 3 15 0 | — |
| Northampton— | | |
| Foundry No. 3 | 3 12 6 | — |
| Forge | 3 7 6 | — |
| Derbyshire— | | |
| No. 3 Foundry | 3 15 0 | — |
| Forge | 3 10 0 | — |
| Scotland— | | |
| Hematite, f.o.t. furnaces | 3 13 6 | — |
| No. 1 Foundry, ditto | 3 12 6 | — |
| No. 3 Foundry, ditto | 3 10 0 | — |
| Basic, d/d (*Less 5/– rebate*) | 3 10 0 | — |
| N.W. Coast— | 3 14 0 d/d Glasgow | |
| Hematite Mixed Nos. | 3 18 6 „ Sheffield | |
| | 4 4 6 „ Birmingham | |

## MANUFACTURED IRON.

| | Home. | Export. |
|---|---|---|
| Lancs.— | £ s. d. | £ s. d. |
| Crown Bars | 9 12 6 | — |
| Best Bars | 10 2 6 | — |
| S. Yorks.— | | |
| Crown Bars | 9 12 6 | — |
| Best Bars | 10 2 6 | — |
| Midlands— | | |
| Crown Bars | 9 15 0 | — |
| Marked Bars (Staffs.) | 12 0 0 | — |
| No. 3 quality | 7 17 6 | — |
| No. 4 „ | 8 10 0 | — |
| Scotland— | | |
| Crown Bars | 9 12 6 | 9 5 0 |
| Best | 10 2 6 | 9 15 0 |
| N.E. Coast— | | |
| Common Bars | 9 12 6 | 8 15 0 |
| Best Bars | 10 2 6 | 9 15 0 |
| Double Best Bars | 10 12 6 | 10 0 0 |

## STEEL.

| | Home. | Export. |
|---|---|---|
| London and the South— | £ s. d. | £ s. d. |
| Angles | 8 10 0 | 7 10 0 |
| Tees | 9 10 0 | 8 10 0 |
| Joists | 8 17 6 | 7 10 0 |
| Channels | 8 15 6 | 7 15 0 |
| Rounds, 3in. and up | 9 10 0 | 8 10 0 |
| „ under 3in. | 8 14 6 | 7 0 0 |
| Flats, 5in. and under | 8 14 6 | 7 0 0 |
| Plates, ¼in. (basis) | 9 0 0 | 7 15 0 |
| „ ⅜in. | 9 5 0 | 8 0 0 |
| „ ½in. | 9 10 0 | 8 5 0 |
| „ ⅝in. | 9 15 0 | 8 10 0 |
| „ ¾in. | 9 10 0 | 8 5 0 |
| North-East Coast— | £ s. d. | £ s. d. |
| Angles | 8 7 6 | 7 10 0 |
| Tees | 9 7 5 | 8 10 0 |
| Joists | 8 15 0 | 7 10 0 |
| Channels | 8 12 6 | 7 15 0 |
| Rounds, 3in. and up | 9 7 6 | 8 10 0 |
| „ under 3in. | 8 12 0 | 7 10 0 |
| Plates, ¼in. | 8 15 0 | 7 15 0 |
| „ ⅜in. | 9 0 0 | 8 0 0 |
| „ ½in. | 9 5 0 | 8 5 0 |
| „ ⅝in. | 9 10 0 | 8 10 0 |
| „ ¾in. | 9 5 0 | 8 5 0 |
| Boiler Plates, ¼in. | 9 5 0 | — |
| Midlands, and Leeds and District— | £ s. d. | £ s. d. |
| Angles | 8 7 6 | 7 10 0 |
| Tees | 9 7 6 | 8 10 0 |
| Joists | 8 15 0 | 7 10 0 |
| Channels | 8 12 6 | 7 15 0 |
| Rounds, 3in. and up | 9 7 6 | 8 10 0 |
| „ under 3in. | 8 12 0 | 7 10 0 |
| Flats, 5in. and under | 8 12 0 | 8 17 6 |
| Plates, ¼in. (basis) | 8 17 6 | 7 15 0 |
| „ ⅜in. | 9 2 6 | 8 0 0 |
| „ ½in. | 9 7 6 | 8 5 0 |
| „ ⅝in. | 9 12 6 | 8 10 0 |
| „ ¾in. | 9 5 0 | 8 5 0 |
| Boiler Plates, ¼in. | 9 7 6 | 7 15 0 |

## STEEL (*continued*).

| | Home. | Export. |
|---|---|---|
| Glasgow and District— | £ s. d. | £ s. d. |
| Angles | 8 7 6 | 7 10 0 |
| Tees | 9 7 6 | 8 10 0 |
| Joists | 8 15 0 | 7 10 0 |
| Channels | 8 12 6 | 7 15 0 |
| Rounds, 3in. and up | 9 7 6 | 8 10 0 |
| „ under 3in. | 8 12 0 | 7 10 0 |
| Flats, 5in. and under | 8 12 0 | 8 17 6 |
| Plates, ¼in. (basis) | 8 15 0 | 7 15 0 |
| „ ⅜in. | 9 0 0 | 8 0 0 |
| „ ½in. | 9 5 0 | 8 5 0 |
| „ ⅝in. | 9 10 0 | 8 10 0 |
| „ ¾in. | 9 5 0 | 8 5 0 |
| Boiler Plates | 9 5 0 | — |
| South Wales Area— | £ s. d. | £ s. d. |
| Angles | 8 7 6 | 7 10 0 |
| Tees | 9 7 6 | 8 10 0 |
| Joists | 8 15 0 | 7 10 0 |
| Channels | 8 12 6 | 7 15 0 |
| Rounds, 3in. and up | 9 7 6 | 8 10 0 |
| „ under 3in. | 8 12 0 | 7 10 0 |
| Flats, 5in. and under | 8 12 0 | 8 17 6 |
| Plates, ¼in. (basis) | 8 17 6 | 7 15 0 |
| „ ⅜in. | 9 2 6 | 8 0 0 |
| „ ½in. | 9 7 6 | 8 5 0 |
| „ ⅝in. | 9 12 6 | 8 10 0 |
| „ ¾in. | 9 10 0 | 8 5 0 |

| Ireland— | Belfast. £ s. d. | Rest of Ireland. £ s. d. |
|---|---|---|
| Angles | 8 12 6 | 8 15 0 |
| Tees | 9 12 6 | 9 15 0 |
| Joists | 9 0 0 | 9 2 6 |
| Channels | 8 17 6 | 9 0 0 |
| Rounds, 3in. and up | 9 12 6 | 9 15 0 |
| „ under 3in. | 9 2 0 | 9 4 6 |
| Plates, ¼in. (basis) | 9 0 0 | 9 2 6 |
| „ ⅜in. | 9 5 0 | 9 7 6 |
| „ ½in. | 9 10 0 | 9 12 6 |
| „ ⅝in. | 9 15 0 | 9 17 6 |
| „ ¾in. | 9 12 6 | 9 15 0 |

### OTHER STEEL MATERIALS.

| | Home. | Export. |
|---|---|---|
| Sheets. | £ s. d. | £ s. d. |
| 10-G to 13-G., f.o.r. | 9 15 0 | 9 0 0 |
| 14-G. to 20-G., d/d | 11 0 0 | 9 5 0 |
| 21-G. to 24-G., d/d | 11 5 0 | 9 10 0 |
| 25-G. to 27-G., d/d | 11 17 6 | 10 2 6 |

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

| Home. | £ s. d. |
|---|---|
| 4-ton lots and up | 13 5 0 |
| 2-ton to 4-ton lots | 13 12 6 |
| Under 2 tons | 15 5 0 |

*Export*: £12 15s. 0d., c.i.f. India.
„ £11 10s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel Ports, 18/9.
Tin-plate Bars, d/d South Wales Works, £5 10s. 0d.

| Billets. | £ s. d. |
|---|---|
| Basic (0·33% to 0·41% C.) | 6 12 6 |
| „ Medium (0·42% to 0·60% C.) | 7 2 6 |
| „ Hard (0·61% to 0·85% C.) | 7 12 6 |
| „ „ (0·86% to 0·99% C.) | 8 2 6 |
| „ „ (1% C. and up) | 8 12 6 |
| Soft (up to 0·25% C.), 500 tons and up | 5 10 0 |
| 100 to 250 tons | 5 17 6 |
| Rails, Heavy, 500-ton lots, f.o.t. | 8 10 0 |
| „ Light, f.o.t. | 7 10 0 |

## FERRO ALLOYS

| | Per Ton. | Per Unit. |
|---|---|---|
| Tungsten Metal Powder | 3/3 per lb. | |
| Ferro Tungsten | 3/– per lb. | |
| Ferro Chrome, 4 p.c. to 6 p.c. carbon | £21 15 0 | 7/– |
| „ „ 6 p.c. to 8 p.c. | £21 0 0 | 7/– |
| „ „ 8 p.c. to 10 p.c. | £21 0 0 | 7/– |
| „ „ Specially Refined | | |
| „ „ Max. 2 p.c. carbon | £34 0 0 | 11/– |
| „ „ „ 1 p.c. carbon | £36 5 0 | 11/– |
| „ „ „ 0·50 p.c. carbon | £37 5 0 | 12/– |
| „ „ „ carbon free | 9½d. per lb. | |
| Metallic Chromium | 2/5 per lb. | |
| Ferro Manganese (loose) 76 p.c. | £10 15 0 home | |
| „ Silicon, 45 p.c. to 50 p.c. | £12 15 0 scale 5/– p.u. | |
| „ „ 75 p.c. | £17 17 6 scale 6/– p.u. | |
| „ Vanadium | 12/8 per lb. | |
| „ Molybdenum | 4/6 per lb. | |
| „ Titanium (carbon free) | 9d. per lb. | |
| Nickel (per ton) | £200 to £205 | |
| Cobalt | 5/6 per lb. | |

## NON-FERROUS METALS.

*Official Prices, November 6th.*

| | | |
|---|---|---|
| Copper— | | |
| Cash | £35 8 9 to £35 11 3 | |
| Three months | £35 16 3 to £35 17 6 | |
| Electrolytic | £40 0 0 to £40 10 0 | |
| Best Selected Ingots, d/d Birmingham | £40 0 0 | |
| Sheets, Hot Rolled | £68 0 0 | |
| | Home. | Export. |
| Tubes, Solid Drawn (basis) | 10½d. | 10½d. |
| „ Brazed (basis) | 10½d. | 10½d. |
| Brass— | | |
| Ingots, 70/30, d/d Birmingham | £33 0 0 to £34 0 0 | |
| | Home. | Export. |
| Tubes, Solid Drawn, 2/1 Alloy | 9½d. | 9½d. |
| „ Brazed | 11½d. | 11½d. |
| Tin— | | |
| Cash | £225 0 0 to £225 10 0 | |
| Three months | £213 0 0 to £213 5 0 | |
| Lead: Cash and forward | £18 0 0 | |
| Spelter: | £16 6 3 to £16 12 6 | |
| Aluminium Ingots (British) | £100 | |

## FUELS.

### SCOTLAND.

| Lanarkshire— | Export. |
|---|---|
| (f.o.b. Grangemouth)—Navigation Uncreened | 13/3 to 13/6 |
| Hamilton Ell | 16/– |
| Navigation Splints | 16/6 |
| Ayrshire— | |
| (f.o.b. Ports)—Steam | 12/9 to 13/– |
| Fifeshire— | |
| (f.o.b. Methil or Burntisland)— | |
| Prime Steam | 14/6 |
| Uncreened Navigation | 12/9 to 13/– |
| Lothians— | |
| (f.o.b. Leith)—Hartley Prime | 13/6 to 14/6 |
| Secondary Steam | 12/6 to 13/– |

### ENGLAND.

| Yorkshire, Manchester— | |
|---|---|
| B.S.Y. Hard Steams | 18/6 to 21/6 |
| Furnace Coke | 14/6 to 17/6 |
| Northumberland, Newcastle— | |
| Blyth Best | 15/– to 15/6 |
| „ Second | 13/9 to 14/– |
| „ Best Small | 10/6 to 11/– |
| Unscreened | 12/6 to 13/6 |
| Durham— | |
| Best Gas | 14/8 |
| Foundry Coke | 19/– to 20/– |

| Sheffield— | Inland. | |
|---|---|---|
| Best Hand-picked Branch | 23/– to 24/– | — |
| South Yorkshire Best | 20/– to 22/– | — |
| South Yorkshire Seconds | 17/– to 18/6 | — |
| Rough Slacks | 8/– to 9/– | — |
| Nutty Slacks | 7/– to 8/6 | — |

### SOUTH WALES.

| Cardiff— | |
|---|---|
| Steam Coals: | |
| Best Admiralty Large | 19/6 |
| Best Seconds | 19/– to 19/4½ |
| Best Dry Large | 18/9 to 19/3 |
| Ordinaries | 18/3 to 18/6 |
| Bunker Smalls | 12/6 to 13/6 |
| Cargo Smalls | 11/6 to 12/6 |
| Dry Nuts | 22/– to 26/– |
| Foundry Coke | 27/– to 40/– |
| Furnace Coke | 19/– to 22/6 |
| Patent Fuel | 21/– |
| Swansea— | |
| Anthracite Coals: | |
| Best Large | 36/– to 40/– |
| Machine-made Cobbles | 41/– to 43/6 |
| Nuts | 40/– to 43/6 |
| Beans | 25/– to 30/– |
| Peas | 19/– to 23/– |
| Rubbly Culm | 11/– to 11/6 |
| Steam Coals: | |
| Large Ordinary | 18/– to 20/6 |

## FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

| Ex Ocean Installation. | Per Gallon. |
|---|---|
| Furnace Oil (0·950 gravity) | 3½d. |
| Diesel Oil | 4d. |

# French Engineering Notes.

*(From our own Correspondent in Paris.)*

**The Navy.**

At the launching of the "Montcalm," which is the fifth of the half-dozen 7600-ton cruisers to leave the stocks, the Minister of Marine, Monsieur Piétri, who presided over the ceremony at the yard of the Forges et Chantiers de la Méditerranée, declared that "France possesses the finest light squadrons in the world and waits to show with pride her battleships." He further announced that the Government would watch carefully over the interests of the country at the forthcoming naval conference in London. Holding the firm conviction that their interests were sacrificed by the Washington Convention, the French are resolved to secure what they regard as their full right at subsequent conferences, and those rights are based upon a measure of defensive strength determined by the length of coastline of home and overseas territories and the maximum distance of a colonial possession from the mother country. Calculated on this basis, the strength of the French navy, they say, should be second only to that of Great Britain. Other matters that complicate the situation are the steady refusal of France to accept naval parity with Italy and the growth of the German navy, which, it is affirmed, will reach about 400,000 tons at the beginning of 1937, while the French strength will be 416,700 tons, this latter figure assuming, of course, the scrapping of all ships built before work began on the new programme of naval construction. Actually, the French tonnage is about 700,000. It includes the old battleships "Lorraine," "Provence," and "Bretagne," which were only recently transformed and reconditioned. The successful carrying out of the programme has revealed the superiority of modern ships adapted to new conditions of naval warfare, and as the light cruisers have outclassed everything before them so it is believed that the new battleships will render old ships obsolete. Therefore, the French compare the strength of the navy with that of Germany within the limits of modern construction. The difficulty in arriving at an armament limitation lies in the special problems of each country which conflict with any general plan of restriction.

**Industrial Decrees.**

The publication by the Government of more than 300 decrees which constitute law pending their ratification by Parliament does not affect industrial interests to any large extent, except so far as it concerns manufacturers of armaments. It will be remembered that before the Chamber of Deputies separated it passed a motion recommending that, from the beginning of next year, the manufacture of armaments should pass into the hands of the State. The motion was regarded as a platonic gesture. Nevertheless, a former decree instituted a tax on the profits of firms manufacturing war material, and a new decree ensures State control over the profits of such firms and the scope of their activities, which means that the State will control the supply of arms to foreign countries. The railway companies are relieved of some of the financial burden imposed upon them by free services rendered to the State, the Post Office Department being now required to pay for such service. Administrative formalities are to be simplified with a view to reducing charges on railway companies. A tax is to be imposed on long-distance road transport; the produce of which will be divided between the State and the Departments interested. There are decrees relating to road safety, and in this connection reference may be made to tests carried out last week on a section of the road between Paris and the Riviera with lighting arrangements that are intended to ensure safe travelling at night. A committee is to be constituted to co-ordinate transport by rail, air, and water in the same way that such co-ordination already exists between rail and road transport. The object of the committee will be to adjust traffic in a manner to ensure that the railways, air services, and inland waterways shall work together to deal with that traffic for which each is specially suitable in the public interest, and thereby avoid competitive efforts to secure traffic outside their respective limits. A decree suppresses the services of the Messageries Maritimes to Australia, which has been carried on at a loss of something like 10 million francs a year. These decrees close the list which the Government was empowered to issue until the end of October. They relate almost wholly to internal organisation, and little has been done to remove barriers to foreign trade which was declared to be urgently necessary for national economic recovery.

**Rhone Navigation.**

Since the Compagnie Nationale du Rhône was formed to carry out its great scheme to provide facilities for navigation between the Lake of Geneva and Marseilles and install hydro-electric power stations, supplies from which would be used for extensive irrigation over arid territories in the South of France, its operations have been limited by the economic depression, as well as by delay in settling upon definite plans. There is no necessity to push forward hydro-electric installations on the Rhône when the production of energy for industrial purposes already far exceeds the demand. A start cannot be made upon the canalisation of the river until it has been decided whether to deepen the river between Lyons and Marseilles or construct a lateral canal, and the method to be employed for utilising the Rhône above Lyons depends upon arrangements that can be made with the Swiss Government, particularly with regard to the level of the Lake of Geneva. Meanwhile the company can only proceed with navigation improvements between Lyons and Marseilles, where a good deal of dredging has been done and bridges have been reconstructed by departmental authorities to allow of more clearance for boats. At Lyons a programme of work has been approved by the Ministry of Public Works, which has provided a credit of 80 million francs out of the relief fund for its execution. The programme consists principally of extensions and improvements to existing basins in Lyons and the creation of an oil depôt in view of the growing oil traffic from Marseilles.

# British Patent Specifications.

*When an invention is communicated from abroad the name and address of the communicator are printed in italics.*

*When an abridgment is not illustrated the Specification is without drawings.*

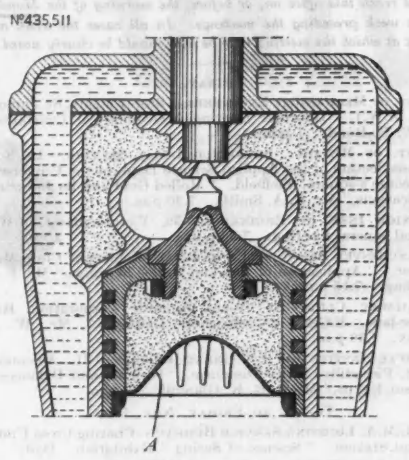
*Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C. 1s. each.*

*The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.*

## INTERNAL COMBUSTION ENGINES.

435,511. December 20th, 1934.—Cooling Pistons, R. Bernard (*née* Bournonville), 11 bis, Avenue du Maréchal Maunoury, Paris (Seine), France (legal representative of Auguste Louis René Bernard, deceased).

The piston of this engine, which is of the compression ignition

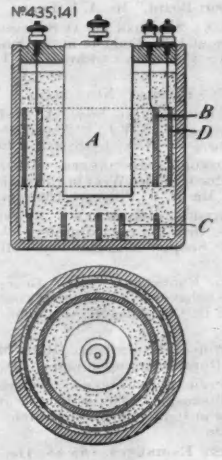



type, is filled with powdered aluminium, held in place by the plate A. This powder is said to improve the cooling of the head of the piston and to keep tight the joints between its several parts.—*September 23rd*, 1935.

## BATTERIES AND ACCUMULATORS.

435,141. April 9th, 1934.—Primary Cells, Société Anonyme Le Carbone, 37–41, Rue de Paris, Gennevilliers (Seine), France.

It sometimes happens that when primary cells are connected in series, or series-parallel, that one or more may be reversed in polarity by an accumulation of oxygen on the negative electrode. This trouble is overcome, according to the invention, by the

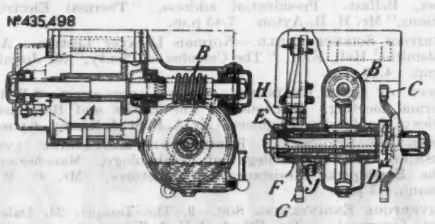



addition of auxiliary negative or soluble electrodes. In the drawing a cell is shown with a positive electrode A and a main negative electrode B. They may be of carbon and zinc respectively. There are also in the cell a spiral zinc electrode C and another auxiliary zinc electrode D, connected up with the main electrode as shown. It appears that the efficacy of the arrangement depends upon the local variation in the concentration of the electrolyte.—*September 16th*, 1935.

## MOTOR CARS AND ROAD TRAFFIC.

435,498. June 9th, 1934.—Brake Mechanism for Electric Trollybuses, Ransomes, Sims and Jefferies, Ltd., and W. Gilbert, Orwell Works, Ipswich.

This is a servo-motor type of brake operated electrically with the power derived from an electric motor A. This motor drives

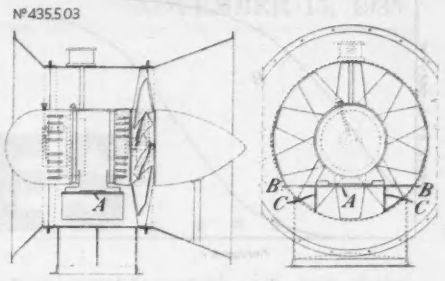



a worm gear B. Loosely mounted on the driven shaft of this gear there is the brake actuating lever C, which can be connected with the worm gear by means of the dog clutch D. This clutch is held out of engagement by the spring E. Another lever F is connected with the brake pedal at G and with the motor starter at H. When the pedal is depressed the first action is to start the motor, further movement of the lever F makes the roller J move along a fixed cam path and draw the shaft to the left, so that the dog clutch D is engaged and the brakes are applied. The pressure on the pedal incidentally helps to operate the brakes.—*September 23rd*, 1935.

## PUMPING AND BLOWING MACHINERY.

435,503. August 27th, 1934.—Axial Flow Fans, F. C. Stewart, 150, Helen-street, Govan, Glasgow.

This invention is concerned with fans of the propeller type, driven by an electric motor, which are installed in confined spaces. The inventor explains that it is usual in such cases to

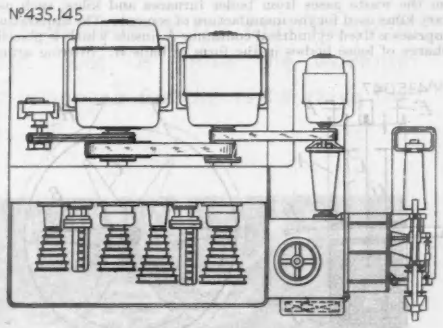



secure the motor in the casing by radial struts, and that then it is difficult to gain access for overhaul and repair. As a consequence, he mounts the motor and propeller on a horizontal plate table A, and arranges the top part of the casing to be demountable, with joints at B B, to provide access to the motor. Stiffening plates are arranged at C C.—*September 23rd*, 1935.

## MACHINE TOOLS AND SHOP APPLIANCES.

435,145. April 28th, 1934.—Wire-drawing Machines, C. A. Barron, Eldon-street Works, Eldon-street, Preston, Lancs.

The inventor proposes to drive each of the drawing pulleys of a continuous wire-drawing machine by means of its own

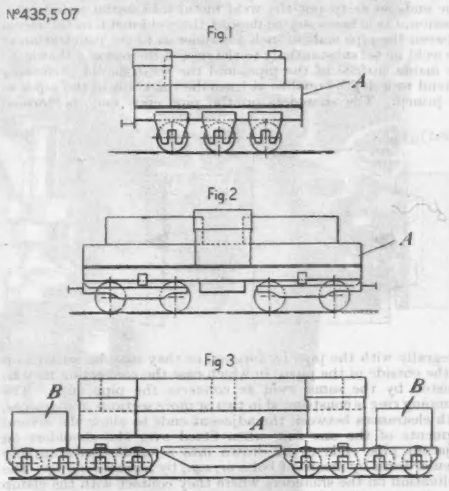



electric motor, the motors being so designed to give the requisite increase in speed as the drawing progresses. Nevertheless, he connects the spindles together by belting as a precaution against the failure of any one of the motors. A special motor is provided for running the machine slowly during the process of stringing up.—*September 16th*, 1935.

## TRAMWAYS AND RAILWAYS.

435,507. November 26th, 1934.—Oil Locomotives, H. Hansen, Amagerbrogade 45, Copenhagen, Denmark, and K. G. Rosenthal, Amagerfælledvej 5, Copenhagen.

The inventors make a claim for a vertical internal combustion engine, particularly a Diesel engine, adapted for use as a driving engine in rail locomotives, rail tractors or similar rail vehicles, characterised in that the frame of the engine is constituted by the engine crank case, which is given such a shape and strength



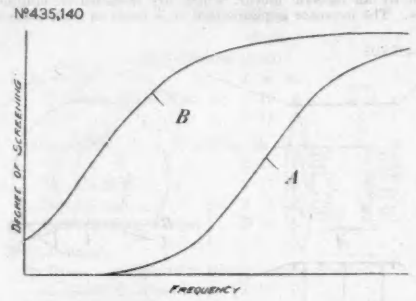

that besides serving as frame for the engine proper, it is adapted at the same time to form the frame or supporting construction of the vehicle. The illustrations show three engines, each with the crank case marked A. In Fig. 1 there is a six-wheeled locomotive with one engine; Fig. 2 shows a bogie arrangement with two engines; and Fig. 3 represents an oil-electric scheme with the driving motors mounted on the bogies at B B. —*September* 23rd, 1935.

## MISCELLANEOUS.

435,140. March 28th, 1934.—Electric Cables, Pirelli-General Cable Works, Ltd., 343–5, Euston-road, London, N.W.1; and J. R. Harding.

This invention has special reference to insulated auxiliary electric cables, such, for instance, as pilot cables, for use in electrical power transmission systems where they are erected (in the case of systems wherein overhead conductors are employed)

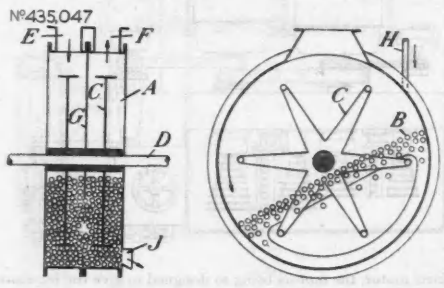
or laid in or on the ground in the neighbourhood of the electrical power lines or cables. In such circumstances it has been found that under certain conditions voltages may be induced in the conductors of such auxiliary cables by currents flowing in the power conductors. For this reason an auxiliary electric cable is provided with an armouring of low resistance consisting, for example, of copper, cadmium copper, copper-clad steel, or aluminium wires. Such low-resistance armouring exercises a big influence in reducing the voltage which would otherwise be induced in the conductors of the cable. For the highest degree of shielding the armouring may comprise segmental wires of copper. For cables carried on overhead lines the armouring may




also be so constructed as to render the cable self-supporting. Electric cables provided with such armouring have the advantage of possessing a resistance to corrosion equal to that of power conductors composed of the armouring material, and higher than that of the usual galvanised steel wires employed for armouring cables. An example of the improved shielding from induction obtained is illustrated in the diagram given in the accompanying drawing, which shows the relative degrees of screening or shielding from induction obtained in the case of a plain lead-sheathed cable (see curve A) and a cable in which the armouring comprises segmental copper wires (see curve B).—*September 16th*, 1935.

435,047. March 13th, 1934.—Apparatus for Washing Dust from Gases, A. Larsen, Rördal, Aalborg, Denmark.

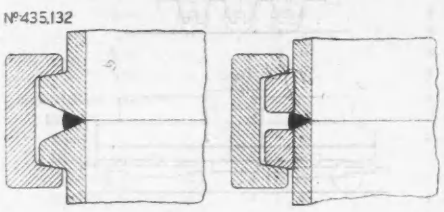
This invention relates to apparatus for washing dust from gases, and is particularly applicable to the separation of dust from the waste gases from boiler furnaces and kilns, such as rotary kilns used for the manufacture of cement. The apparatus comprises a fixed cylindrical container A, inside which is placed a charge of loose bodies in the form of balls B. Stirring arms




C are provided on a rotary shaft D. Dust-laden air is introduced through an inlet E and passes through the container to an outlet F, being forced to pass through the loose bodies B by a transverse partition G furnished with an opening in that part which lies within the loose bodies when the apparatus is in use. Water is supplied through a pipe H and keeps the surfaces of the loose bodies moist. This water carries away the dust in the form of a slurry by the outlet J.—*September 13th*, 1935.

435,132. March 16th, 1934.—Pipe Joints, Leonard Close, Norton Hall, The Green, Norton-on-Tees, County Durham; and Imperial Chemical Industries, Ltd., Imperial Chemical House, Millbank, London, S.W.1.

Pipes or cylinders are connected end to end by depositing weld metal in a recess formed between the pipe ends, and each pipe is provided with a tapered shoulder adjacent to the recess. A clamping ring, in sections, embraces the shoulders of the adjacent pipe ends so as to put the weld metal into initial radial compression. It is necessary to deposit the weld metal in the recess between the pipe ends in such a manner as to get penetration of the weld metal substantially to the root of the recess; that is, to the inside surface of the pipe, and the weld should preferably extend to a depth equal to at least the thickness of the pipes to be joined. The shoulders on the pipe ends may be formed




integrally with the pipe by forging, or they may be screwed on to the outside of the pipes, in which case the connection may be assisted by the same weld as connects the pipe ends. The clamping ring is constructed in two or more sections or segments, with clearances between the adjacent ends to allow the several segments of the one ring when fitted over the shoulders on adjacent pipe ends to be drawn into a smaller substantially circular form by means of bolts or, *e.g.*, by hammer blows. The inclination on the shoulders where they contact with the clamp ring is so small that a small centripetal force causes a comparatively large thrust to be brought on the weld between the pipe ends, whilst the clamping ring, once drawn on the shoulders, remains securely in position by friction and additional holding members, such as bolts, are not essential for holding the clamp ring segments in position.—*September 16th*, 1935.

435,334. May 25th, 1934.—The Seasoning Treatment of Peeled Wood Veneers, H. A. Hellmers, Holstenstrasse 56, Kiel, Germany, and Mersida Veneers, Ltd., 31–34, Basinghall-street, London, E.C.2.

This invention has reference to the preparation or "seasoning" of peeled wood veneers for various uses. The peeled wood veneers having been cut into lengths of the desired extent are inserted or passed into or through a bath containing a solution or mixture of the following ingredients in or about the proportions stated:—Formalin, 3 parts; chrome alum, 1 part; gelatine, 1 part; glycerine, 10 parts; water, 85 parts. The period of immersion or steeping in the aforesaid bath would be about one minute, but this period varies according to the kind of wood treated. The proportions of the several ingredients of the mixture or composition will require some adjustment in treating woods of different character, in order to obtain the desired effect, but the proportions given are those which have been found to give good results when treating the wood veneers ordinarily employed in connection with the preparation thereof for use in arts of the kind hereinbefore referred to. By the use of a bath of the above described composition and by subjecting the peeled wood veneers after treatment therein to drying as ordinarily adopted, what is known in the art as "working" of the wood is, say the inventors, prevented, and the veneer assured of possessing the required pliability and flexibility.—*September 20th*, 1935.

## Forthcoming Engagements.

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the* TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

To-day,

Inst. of Mechanical Engineers.—Storey's-gate, St. James's Park, S.W.1. Informal meeting, "Geometrical Constants," Dr. W. N. Bond. 7 p.m.

Inst. of Metals: Sheffield Local Section.—In Non-Ferrous Section of the Applied Science Dept. of the University, St. George's-square, Sheffield. "Rolled Gold and its Industrial Applications," Mr. E. A. Smith. 7.30 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. Annual general meeting. 7.30 p.m.

Manchester Assoc. of Engineers.—Engineers' Club, Manchester. "Application of Ball and Roller Bearings," Mr. F. O. Hickling. 7.15 p.m.

Railway Club.—At Royal Scottish Corporation Hall, Fetter-lane, E.C.4. "Continental Railways," Mr. W. A. Willox. 7.30 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, Piccadilly, W.1. Discourse, "Weights and Balances in Ancient Egypt," Mr. S. R. K. Glanville. 9 p.m.

To-day to Friday, Nov. 15th.

E.L.M.A. Lighting Service Bureau.—Charing Cross Underground Station. "Science of Seeing" Exhibition. Daily.

To-day to Saturday, Nov. 16th.

Commercial Motor Transport Exhibition.—Olympia, Kensington, W. Open daily.

Saturday, Nov. 9th.

Inst. of Electrical Engineers: N. Midland Students.—Visit to *Yorkshire Evening News*, Leeds. 3 p.m.

Inst. of Marine Engineers: Junior Section.—85–88, The Minories, E.C.3. Dance. 7.30–11.15 p.m.

Monday, Nov. 11th.

Chartered Surveyors' Inst.—12, Gt. George-street, S.W.1. Presidential address, Mr. H. M. Stanley. 6.30 p.m.

Inst. of Electrical Engineers: N. Eastern Centre.—Armstrong College, Newcastle-upon-Tyne. "Equipment and Performance of Steel Tank Rectifier Traction Sub-stations Operating on the Underground Railways of the London Passenger Transport Board," Mr. A. L. Lunn. 7 p.m.

Inst. of Metals: Scottish Local Section.—In Rooms of Inst. of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. Chairman's address, Mr. J. W. Donaldson. 7.30 p.m.

Tuesday, Nov. 12th.

Illuminating Engineering Soc.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "Visual Perceptions under Modern Conditions," Dr. R. V. Lythgoe. 6.30 for 7 p.m.

Inst. of Automobile Engineers.—At the Geisha Café, Coventry. "Undue Cylinder Wear in Internal Combustion and Steam Engines," Mr. H. J. Young. 7.30 p.m.

Inst. of British Foundrymen: Burnley Section.—Municipal College, Ormerod-road, Burnley. "Castings Viewed from the Machine Shop *vs* Machinability," Mr. John Jackson. 7.15 p.m.

Inst. of Civil Engineers.—Great George-street, S.W.1. Discussion, "The Behaviour of Reinforced Concrete Piles during Driving," Dr. W. H. Glanville, Mr. G. Grime, and Mr. W. W. Davies. 6 p.m.

Inst. of Electrical Engineers.—Hotel Metropole, Leeds. "Design Data in Rural Distribution Lines," Mr. R. Dean. 7 p.m.

Inst. of Electrical Engineers: Scottish Centre.—In the Engineers' Rooms, 39, Elmbank-crescent, Glasgow, C.2. "Recent Progress in Induction Motor Construction," Mr. L. H. A. Carr. 7.30 p.m.

Inst. of Marine Engineers.—85–88, The Minories, E.C.3. "Developments in the Measurement of Torque and Thrust in Ships," Mr. V. W. H. Towns. 6 p.m.

Inst. of Metals: N. East Coast Local Section.—Joint meeting with Newcastle branches of Soc. of Chemical Industry and Inst. of Chemistry. At Armstrong College, Newcastle-upon-Tyne. "The Manufacture of Zinc," Mr. Stanley Robson. 7.30 p.m.

Inst. of Metals: Swansea Local Section.—Y.M.C.A., Swansea. Chairman's address, Mr. Roosevelt Griffiths. 6.30 p.m.

Sheffield Metallurgical Assoc.—198, West-street, Sheffield, 1. "Laboratory Work Fifty Years Ago," Mr. H. Brearley. 7.30 p.m.

University of London: King's College.—Strand, W.C.2.—"The History of Mechanical Invention," Mr. H. W. Dickinson. 5.30 p.m.

Wednesday, Nov. 13th.

Belfast Assoc. of Engineers.—Queen's Hotel, Victoria-street, Belfast. Presidential address, "Thermal Electric Stations," Mr. H. R. Ayton. 7.45 p.m.

British Science Guild.—Norman Lockyer Lecture. At Goldsmiths' Hall, E.C. "The Calculus of Plenty," Sir Josiah Stamp. 4.30 p.m.

Inst. of Civil Engineers.—Great George-street, S.W.1. Informal meeting. Discussion, "The Duties and Responsibilities of the Resident Engineer," Mr. A. F. St. J. Kinsey. 6 p.m.

Inst. of Structural Engineers: Lancashire and Cheshire Branch.—College of Technology, Manchester. "The Earthquake Resistance of Structures," Mr. C. W. Hamann. 7 p.m.

Liverpool Engineering Soc.—9, The Temple, 24, Dale-street, Liverpool. "The Effect of High Temperature on the Properties of Steel," Mr. W. Barr. 6.30 p.m.

Newcomen Soc.—At Inst. of Structural Engineers, 10, Upper Belgrave-street, S.W.1. Annual general meeting. "The English Dwelling-house Before the Tudors," Mr. S. B. Hamilton and Mr. P. H. Mellor. 5.30 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. Lecture by Sir Albert Howard. 8 p.m.

Thursday, Nov. 14th.

Inst. of Automobile Engineers.—At Merchant Venturers' Technical College, Bristol. "Small Car Engines," Mr. L. J. Shorter. 7 p.m.

Inst. of Structural Engineers.—10, Upper Belgrave-street, S.W.1. "Some Bridge and Foundation Problems," Mr. Leslie Turner. 6.30 p.m.

Friday, Nov. 15th.

Chemical Engineering Group.—In Rooms of Chemical Soc., Burlington House, Piccadilly, W.1. "The Handling and Storing of Acids," Mr. T. J. Dixon and Dr. F. Roffey. 8 p.m.

Inst. of British Foundrymen: Sheffield Branch.—Grand Hotel, Sheffield. "Refractories in the Foundry," Mr. W. J. Rees. 7.45 p.m.

Inst. of Electrical Engineers: Meter and Instrument Section.—Pagani's Restaurant, 42, Gt. Portland-street, W.1. Annual dinner, 6.45 for 7 p.m.; concert and reunion, 9.30 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. "Notes on Small Injectors and Ejectors," Mr. L. M. G. Ferreira. 7.30 p.m.

North-East Coast Inst. of Engineers and Shipbuilders.—At Mining Inst., Newcastle-upon-Tyne. "Shipbuilding by Welding," Mr. Norman M. Hunter. 6 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, Piccadilly, W.1. Discourse, "The Synthesis of a Natural Colouring Matter," Dr. Robert Robinson. 9 p.m.

Societe des Ingenieurs Civils de France: British Section.—Joint meeting with the Inst. of Mechanical Engineers, the Inst. of Naval Architects, and Inst. of Electrical Engineers, at the Inst. of Electrical Engineers, Savoy-place, W.C.2. Monsieur P. de Malglaive will read a lecture on the s.s. "Normandie," by Monsieur J. Marie. 5.30 for 6 p.m.

Monday, Nov. 18th.

Engineers' German Circle.—At Inst. of Mechanical Engineers, Storey's-gate, S.W.1. "Neuzeitlicher Segelflug," Herr Robert Kronfeld. 5.30 for 6 p.m.

Inst. of Automobile Engineers.—At Inst. of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.2. Presidential address, Mr. A. J. Hancock. 7.45 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. Cantor Lecture, "Geological Aspects of Underground Water Supplies," Dr. Bernard Smith. 8 p.m.

Sheffield Soc. of Engineers and Metallurgists.—Joint meeting with Sheffield Metallurgical Assoc., Mappin Hall, St. George's-square, Sheffield. Discussion on Iron and Steel Institute's Special Report, No. 10, "Waste Heat Boilers in Open-hearth Practice." 7.30 p.m.

Wolverhampton and District Engineering Soc.—Victoria Hotel, Wolverhampton. "Recent Developments in the Production of Non-ferrous Strip and Sheet," Mr. G. A. V. Russell. 7.30 p.m.

Monday to Saturday, Nov. 18th to 23rd.

Public Works, Roads and Transport Congress and Exhibition, 1935.—Royal Agricultural Hall, Islington, N.1. For programme of meetings, see page 426, October 25th, 1935. Open daily.

Tuesday, Nov. 19th.

Inst. of Automobile Engineers.—Cavendish Café, Cornmarket, Derby. "Small Car Engines," Mr. L. J. Shorter. 7.30 p.m.

Inst. of Engineers and Shipbuilders in Scotland.—39, Elmbank-crescent, Glasgow, C.2. "Voith-Schneider Propulsion," Mr. W. J. F. Clere and Capt. E. C. Goldsworthy. 7.30 p.m.

Sheffield Metallurgical Assoc.—198, West-street, Sheffield, 1. "High-speed Cinema Photography with Precision Timing Device and Possible Applications to Research," films, Mr. D. B. Foster. 7.30 p.m.

University of London: King's College.—Strand, W.C.2.—"The History of Mechanical Invention," Mr. H. W. Dickinson. 5.30 p.m.

Wednesday, Nov. 20th.

Electrodepositors' Technical Soc.—Northampton Polytechnic Inst., St. John-street, E.C.1. Annual meeting. Presidential address, Mr. E. A. Ollard. 8.15 p.m.

Industrial Welfare Soc.—14, Hobart-place, Westminster, S.W.1. Annual general meeting. 4 p.m.

Inst. of Automobile Engineers.—Hotel Metropole, Leeds. "Undue Cylinder Wear in Internal Combustion and Steam Engines," Mr. H. J. Young. 7.15 p.m.

Inst. of Chemical Engineers.—In Rooms of Chemical Soc., Burlington House, Piccadilly, W.1. "The Evaporation of Water from Plane and Cylindrical Surfaces," Mr. R. W. Powell and Dr. Ezer Griffiths, F.R.S. 6 p.m.

Inst. of Structural Engineers: Scottish Branch.—129, Bath-street, Glasgow. "Reinforced Concrete Structures for the Retention of Water and Other Fluids," Mr. W. Hunter Rose. 7.15 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. "Art Training for Industry on the Continent," Mr. Francis A. Taylor. 8 p.m.

Thursday, Nov. 21st.

Inst. of Marine Engineers.—Joint meeting at L.C.C. School of Engineering and Navigation, Poplar, E. "Welding in Marine Repair Work," Mr. R. S. Kennedy. 7 p.m.

Inst. of Structural Engineers: Yorkshire Branch.—Hotel Metropole, Leeds. "Vibration and Pervibration in Concrete Depositing," Mr. T. J. Gueritte. 7 p.m.

Friday, Nov. 22nd.

Inst. of British Foundrymen: Junior Section, Lancashire Branch.—College of Technology, Manchester. "Practical Foundry Experiences," Mr. J. Sherwood. 7.30 p.m.

Inst. of Electrical Engineers: N.-Eastern Students.—Grand Assembly Rooms, Barras Bridge, Newcastle-upon-Tyne. Annual dance.

Inst. of Structural Engineers: Midland Counties Junior Members.—James Watt Memorial Inst., Birmingham. "Some Notes on Concrete," Mr. H. W. Coultas. 6.30 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. Informal meeting. Lecture, "The Correlation of Mining with Engineering," Mr. Alexander Reid. 7.30 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, Piccadilly, W.1. Discourse by Dr. John Read. 9 p.m.

Monday, Nov. 25th.

Inst. of Mechanical Engineers: Graduates.—Storey's-gate, S.W.1. "Oil," Mr. R. A. Robbins. 6.15 for 6.45 p.m.

Royal Aeronautical Soc.—At Inst. of Electrical Engineers, Savoy-place, W.C.2. "Sound Proofing of Aircraft," Dr. S. J. Zand. 5.30 for 6 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. Cantor Lecture, "Geological Aspects of Underground Water Supplies," Dr. Bernard Smith. 8 p.m.

Tuesday, Nov. 26th.

Inst. of Automobile Engineers.—At James Watt Memorial Inst., Birmingham. "Cylinder Materials and Finish from the Users' Point of View as Distinct from that of the Castings Manufacturer," Mr. K. Brozyna. 8 p.m.